臺灣省農業試驗所簡研究員錦忠博士研究論文主要代表作

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優良稻種對葉稻熱病抵抗性之比較初步報告*

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一、試 驗 目 的

比較各種優良稻品種間對葉稻熱病抵抗性之差異，以供栽培、推廣或育種之參考。

二、試驗材料及方法

所比較之優良稻品種，包括蓬萊稻51種，在來稻37種。經民國 42, 43, 44年 3 年中於每一期稻作施行田間觀察；並於43年苗期時舉行 6 次人工稻熱病接種。

三、試 驗 結 果

在此88種稻品種中，均可以發生稻熱病病斑，其有差異者即病斑之易否擴張，不易擴張者於本文稱為 I 抗病品種。因目前抗病稻品種極少，適宜栽培地區有限，為配合優良稻之推廣，特將病斑易擴張之稻品種，依其病斑數目之多寡及枯死情形，分 II，III，IV 種程度區別之，以資參考。本試驗初步整理所得結果列於下表：

抗病程度	罹病情形	稻種名稱
I 抗病品種	於苗或本田葉上之病斑，呈現褐色小點，不易擴張，對稻生長無影響。	光復 1 號，嘉農育 242 號，嘉農育 280 號，高雄大粒清油，臺中菜園種，高雄白葉，臺東烏粒，臺中蟻公包，鈎連粘，高雄烏殼清油等10種。
II 比較抗病品種	a. 在來稻：苗葉病斑外緣褐色，內部灰色或較淺之褐色，病斑有時擴張，但苗很少因此而枯死，本田多半較一般蓬萊稻抗病，隅而亦有枯萎之葉片發生。	臺北烏殼，宜蘭白殼軟枝，臺北柳頭仔，新竹雷槌，新竹清油，宜蘭長尾尖，花蓮柳州，臺中白殼，新竹火燒仔烏占，新竹蟻公包，新竹高脚烏占，新竹花螺，低脚烏占，臺中烏尖 2 號，臺中低脚烏尖，牛天仔，嘉義格仔，蟻公包，田賦種，低脚，高雄蟻公包，高雄烏粒，臺東烏擔，臺東烏占，臺北低脚柳州，江西 3613，永安冷水白，臺北短廣花螺，黑督 4 號，中農 4 號共30種。
	b. 蓬萊稻：苗葉病斑灰色，成大面積之圓形或橢圓形，能使稻苗直接青枯。但後期於本田，因病斑數目發生較少，而多具有抗病能力。	新農育14號；臺中 155 號；嘉南 2 號；高雄10, 18, 22, 25, 27號；高雄育38, 42, 44 號；花蓮 5 號等12種。
III 微有抗病力之品種	苗葉病斑與 II b. 相同，在本田病斑數目較多，但全株枯死者尚屬少見。	農育1805，2019號；新農育17, 24, 31, 72, 73, 76 號；臺中育43號，臺中 150，153號；光復 401 號；高雄24號；高育38, 45號；吉野 1 號，吉神 × Banda 等17種。
IV 感病品種	苗葉病斑與 II b. 相同，在本田如遇稻熱病發生，多易成災，影響產量。	農育 2092，2136號；臺北 7, 8, 11, 121號；新竹50；臺中育48；臺中65, 117, 122 號；嘉南 8, 14, 15號；南育 484, 485, 508號；高雄53號；花蓮17號等19種。

註：相同抗病程度內之品種名稱，其前後次序與抗病強弱無關。

* 抽印自中華農學會報新第十二期第 89～90 頁（年會論文摘要）1955

四、結　　論

光復1號，嘉農育242號及嘉農育280號爲蓬萊稻中僅有之抗稻熱病品種，在第一期稻作適宜栽培之地區，應盡量推廣。其他Ⅱb苗期及Ⅲ、Ⅳ全期所屬品種要注意栽培方法與施用有效藥劑，以減少稻熱病之爲害。

農業研究 6(3):41-46 (1956)

西樂生石灰(Ceresan Lime)防治稻熱病之效果

(預　報)

簡　錦　忠

一、緒　　言

稻熱病的發生，可影響稻米產量，如欲避免病害猖獗，宜 (1) 栽培抗病性品種，(2) 改進栽培方法，(3) 應用殺菌劑防治。今經多方努力研究，雖略有進步，但尚未消滅其病害。故應用殺菌劑之防治，仍有繼續試驗研究之必要。

澤田氏(1926)曾應用銅石驗液防治葉稻熱病，效果不顯著，迨1935年在稻出穗期撒佈過石灰波爾多液 (6斗～1石式)，結果在施用氮肥標準區者，被害率可減少 10～22 %，又施氮肥增加至 2.5 倍，則可減少 30～40 %。橋岡氏(1950)亦應用 3～9 式過石灰波爾多液，其效果却不顯著，乃復於 1939～1941 年在播種前舉行種子消毒，並於本田撒佈加展着劑之 4～6 式過石灰波爾多液，其效果則較顯著。又1942年臺灣總督府農業試驗所曾以 4～8 式過石灰波爾多液防治，亦得良果。

由上看來，本省稻熱病之防治，大都應用液劑石灰波爾多合劑或其他銅劑，效力較差，非撒佈多次不可。二次大戰後，各國對農用殺菌劑，特加研究，很多新出品的殺菌劑，亦爲防治植物病害所採用。數年前日本開始應用 Ceresan 加石灰來防治稻熱病，1953年發表其有效結果，於是推廣全國。

前年本所徐所長水泉赴美、日考察，返國曾携 Ceresan 石灰，供作者採爲試驗材料。茲將初步試驗結果，介紹如次，俾供稻熱病防治之參考。本試驗蒙徐所長、洪技正章訓、臺大陳教授其昌熱忱指導與勉勵，附此併致謝意。

二、材料及方法

A. 材料：

供試藥劑應用 Ceresan 石灰〔0.6% ethyl mercury chloride (Hg. 0.25%)，日本特殊農藥製造公司出品〕及石灰波爾多液 (Bordeaux mixture) (4～8 式)；供試稻種爲臺中65號及崑山五香粳。人工接種所用之病原菌，係1954年由臺中65號之葉部病斑所分離者，該病原菌懸浮液先接種於崑山五香粳，迨其發生稻熱病後，再採其罹病葉用以製成接種原。

B. 方法：

1. 室內試驗：將稻苗由田間移植於室內砵中，經一星期後即供試驗，其處理分爲①撒佈藥劑後接種病原，②接種病原後撒佈藥劑及③撒佈藥劑即噴水，然後再接種病原。各區接種病原後保持適當濕度，逾24小時再行放置玻璃室內，經一定期間後，觀察各區之罹病情形。

2. 田間試驗：肥料施量，以每公頃 N 160 公斤，P_2O_5 60公斤，K_2O 50公斤。藥劑撒佈處理分爲 2 次區及 3 次區。每次撒佈 Ceresan 石灰，係每10公畝爲 3 公斤，石灰波爾多液每 10 公畝爲 400～500 公升。其他尙有僅當稻出穗前撒佈一次，或出穗前後各撒佈一次等，然後觀察其效果。

三、結　　果

A. 室內試驗結果：

表一 Ceresan 石灰與石灰波爾多液防治效果之比較

處理 / 藥劑	接種後撒佈藥劑區						撒佈藥劑後接種區						撒佈藥劑後即刻噴水再接種區					
	撒佈藥劑日期(接種後日數)	調査葉數	罹病葉百分率 %	病斑數	每葉病斑平均數	ck 指數爲100	撒佈藥劑日期(接種前日數)	調査葉數	罹病葉百分率 %	病斑數	每葉病斑平均數	ck 指數爲100	撒佈藥劑日期(接種前日數)	調査葉數	罹病葉百分率 %	病斑數	每葉病斑平均數	ck 指數爲100
對 照(ck)		83	48.2	42	0.506	100.0		50	20.0	26	0.520	100.0		53	18.9	23	0.434	100.0
Ceresan 石灰	0	71	0	0	0.000	0.0	7	75	14.7	22	0.293	56.3	7	67	11.9	10	0.149	34.3
	1	71	2.8	3	0.042	8.3	6	78	10.3	19	0.244	46.9	6	100	6.0	11	0.110	25.3
	2	76	0	0	0.000	0.0	5	70	7.1	7	0.100	19.2	.5	74	5.4	4	0.054	12.4
	3	62	9.7	8	0.129	25.5	4	94	6.4	10	0.106	20.4	4	69	5.8	5	0.072	16.6
	4	88	14.8	19	0.216	42.7	3	82	9.8	11	0.134	25.8	3	88	1.1	1	0.011	2.5
	5	66	13.6	14	0.212	41.9	2	73	0.0	0	0.000	0.0	2	99	0.0	0	0.000	0.0
	6	64	14.1	13	0.203	40.1	1	72	0.0	0	0.000	0.0	1	70	0.0	0	0.000	0.0
	7	61	19.7	21	0.344	68.0	0	72	0.0	0	0.000	0.0	0	62	0.0	0	0.000	0.0
石灰波爾多液	0	68	1.5	2	0.029	5.7	7	116	15.5	41	0.353	67.9	7	72	15.3	17	0.236	54.4
	1	67	19.4	30	0.448	88.5	6	61	27.9	17	0.279	53.7	6	65	10.8	11	0.169	38.9
	2	80	6.3	11	0.138	27.2	5	63	14.3	18	0.286	55.0	5	51	13.7	7	0.137	31.6
	3	68	16.2	24	0.353	69.2	4	57	15.7	24	0.421	81.0	4	74	13.5	12	0.162	37.3
	4	74	13.5	32	0.432	85.4	3	68	13.2	24	0.353	67.9	3	87	12.6	22	0.254	58.5
	5	95	26.3	43	0.453	89.5	2	77	6.5	9	0.117	22.5	2	53	11.3	6	0.113	26.0
	6	91	17.6	26	0.285	56.3	1	84	10.7	19	0.226	43.5	1	73	15.1	14	0.191	44.0
	7	64	17.2	21	0.325	64.8	0	49	6.1	7	0.147	26.3	0	62	4.8	4	0.048	11.1

本試驗開始於1955年 4 月 7 日，由田間移植於室內砵中，每砵插 2 穴，共 102 砵，並每砵施硫酸銨 2 公分。其處理分爲①移植一星期後開始接種病原，而後逐日撒佈藥劑各一次，4 月28日觀察記錄；②每隔一天撒佈藥劑一次，每次分砵撒佈，迨全部撒佈之最後一天，並即全部洒水，風乾後接種病原，5 月 3 日觀察記錄；③其撒佈藥劑方法與②同，但不洒水，5 月 4 日觀察記錄。茲將結果列於表一。

由上表看來 Ceresan 石灰之治療效果約 1～2 日，預防者約 3 日，撒佈藥劑後洒水者，其效果與無洒水者略同。處理區之發病狀況雖無直線型之傾向，而其撒佈藥劑距接種時間越久則其發病程度越高，故 Ceresan 石灰之防治效果較石灰波爾多液爲優。

B. 田間試驗結果：

1. Ceresan 石灰與石灰波爾多液防治稻熱病之比較

插秧日期爲1955年 3 月 4 日，撒佈藥劑日期係 4 月15日(插秧後第43日)，4 月26日 (插秧後第54日)，5 月11日(插秧後第69日)及 5 月26日(插秧後第84日)。

茲將觀察結果列表如次。(表2, 3, 4)

表二　防治葉稻熱病之效果

品種	藥劑	插秧後撒佈藥劑日數 第1回	第2回	被感染之葉數 每葉病斑數 0	1	2	3	4	5	6	7	8	9	10以上	調查總葉數	每葉平均病斑數
臺中65號	對照	0	0	366	56	44	33	17	15	11	12	9	8	30	601	1.84
	Ceresan 石灰	43	69	470	28	24	16	6	2	3	1	1			551	0.35
	石灰波爾多液	43	69	466	26	24	10	8	1	5					540	0.32
	Ceresan 石灰	54	69	531	29	11	11	1		1	1				585	0.22
	石灰波爾多液	54	69	450	30	37	16	9	4	1	1	1	1		550	0.43
崑山五香粳	對照	0	0	392	63	56	48	35	13	16	7	4	9	8	651	1.36
	Ceresan 石灰	43	69	491	61	37	28	13	8	6	4		1		649	0.59
	石灰波爾多液	43	69	505	41	36	11	9		1					603	0.32
	Ceresan 石灰	51	69	609	29	14	3	1							656	0.11
	石灰波爾多液	54	69	504	26	15	8	4			1				558	0.23

註：調查日期：1955年 5 月12日

表三　防治穗稻熱病之效果

品種	藥劑	插秧後撒佈藥劑日數 第1回	第2回	第3回	被害株數 % 0	1～10	11～20	21～30	31～40	41～50	51～60	61～70	71～80	81～90	91～100	調查總株數	每株平均被害率
臺中66號	對照	0	0	0	1	2	7	18	27	17	11	8	4	2	3	100	41.5
	Ceresan 石灰	43	69	84	15	34	38	11	1	1						100	11.3
	石灰波爾多液	43	69	84	5	26	41	22	5	1						100	14.9
	Ceresan 石灰	54	69	0	10	30	34	22	2	1	1					100	14.3
	石灰波爾多液	54	69	0	10	22	39	24	3	1		1				100	14.6
崑山五香粳	對照	0	0	0			1	8	10	18	12	11	17	8	15	100	61.3
	Ceresan 石灰	43	69	84	48	22	23	6	1							100	4.0
	石灰波爾多液	43	69	84	35	22	30	10	3							100	8.4
	Ceresan 石灰	54	69	0	39	38	18	3	1				1			100	4.5
	石灰波爾多液	54	69	0	2	14	41	18	11	8	4	2				100	22.2

註：調查日期：臺中65號係 7 月 8 日；崑山五香粳係 6 月30日

表四　產量之比較　（公分/坪）

藥劑名	插秧後撒佈藥劑日數			臺中65號				崑山五香粳			
	第1回	第2回	第3回	乾燥重量	精選重量	精選重量對照區爲100之指數	秕重量	乾燥重量	精選重量	精選重量對照區爲100之指數	秕重量
對照	0	0	0	1,273	1,093	100.0	175	798	675	100.0	123
Ceresan 石灰	43	69	84	1,415	1,360	124.4	55	1,018	948	140.4	82
石灰波爾多液	43	69	84	1,275	1,213	111.0	62	1,013	888	130.1	125
Ceresan 石灰	54	69	0	1,408	1,355	124.0	53	1,025	943	139.7	70
石灰波爾多液	54	69	0	1,275	1,208	109.6	67	875	810	120.0	65

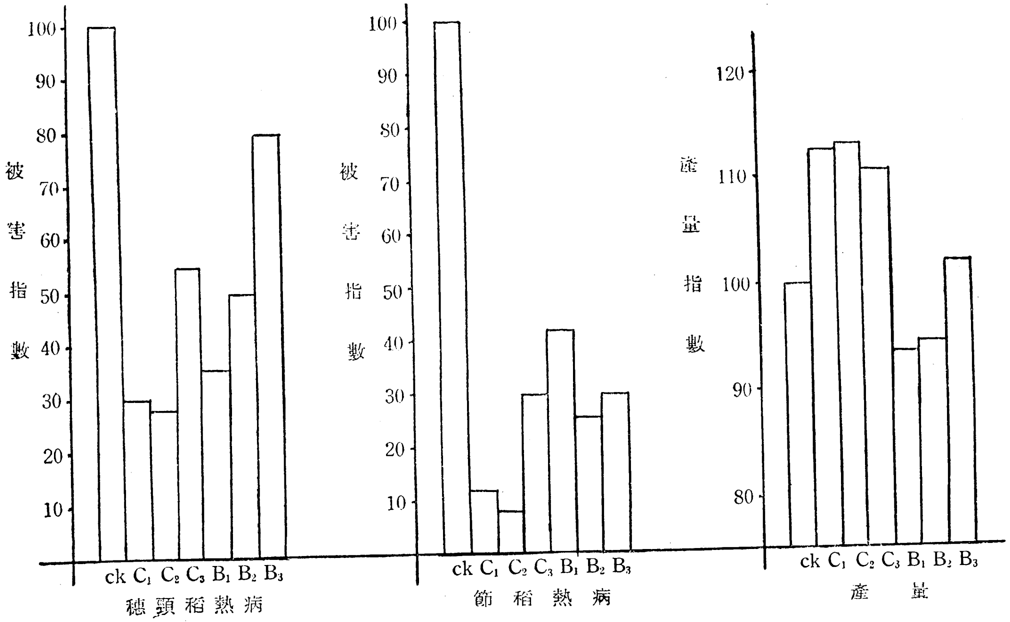
註：收穫日期：臺中65號係7月9日；崑山五香粳係6月30日

由上表得悉，撒佈殺菌劑區之葉稻熱病比對照區皆減少被害，又防治穗稻熱病，如臺中65號撒佈 Ceresan 石灰3次比撒佈2次效果較高，以對照區之被害率爲100％，前者爲27.2％；後者爲34.5％。撒佈石灰波爾多液者，無論撒佈2次或3次，其效果之差異均不顯著。崑山五香粳則具有明顯之差異。因該品種比臺中65號早熟，而且對稻熱病之感染性較易，故撒佈時期應特別注意。又據表4之結果，撒佈 Ceresan 石灰者，與對照區比較；其精選谷重量可減少 24～40％ 之損失，石灰波爾多液爲10～13％。

2　出穗前後撒佈藥劑預防穗頸及節稻熱病效果之比較

此試驗插秧日期1955年3月2日，施肥料每10公畝之基肥爲硫酸錏20公斤，過燐酸石灰20公斤，硫酸鉀10公斤，追肥硫酸錏分爲第1次15公斤，第2及第3次均10公斤。撒佈藥劑在出穗前者係5月26日，出穗後者係6月8日。

其觀察結果如下圖：



圖一　稻出穗前後撒佈藥劑防治穗頸、節稻熱病之效果及對產量之影響（CK爲100之指數）

註：C_1＝稻出穗前撒佈 Ceresan 石灰
C_2＝稻出穗前及後撒佈 Ceresan 石灰
C_3＝稻出穗後撒佈 Ceresan 石灰
CK＝無撒佈區
B_1＝稻出穗前撒佈石灰波爾多液
B_2＝稻出穗前及後撒佈石灰波爾多液
B_3＝稻出穗後撒佈石灰波爾多液

由上圖得知，在出穗前及出穗前後撒佈 Ceresan 石灰者，可減少稻熱病之爲害，無撒佈區之被害指數爲 100 ，則其發生程度，僅爲30左右。石灰波爾多液之效果較差，防治節稻熱病之效果亦略同。

出穗前後撒佈 Ceresan 石灰者，對產量之影響，若以無撒佈區之產量爲 100，則撒佈區可達 110 以上。

四、摘　　要

1. Ceresan 石灰防治稻熱病之效果，較石灰波爾多液爲佳，但距病原接種日期越久，效力越低。先撒佈藥劑而後洒水，其保護作用可達 3 天，石灰波爾多液則不及之。

2. 穗稻熱病之防治，兩種藥劑撒佈 3 次者其效果較 2 次者爲高。

3. 撒佈 Ceresan 石灰者與對照區比較，其產量可減少 20～40 %之損失，石灰波爾多液爲 10～25%。

4. 當出穗前後撒佈 Ceresan 石灰，與對照區比較，對穗稻熱病之被害率可減少 45～70%，石灰波爾多液者約 20～65%。僅于出穗後撒佈一次者，其效果則不及前者。

5. 節稻熱病之防除，當出穗前後撒佈者較爲有效。

6. 無論出穗前抑後僅撒佈 Ceresan 石灰一次者，與對照區比較，其產量均可減少 10～13 %之損失，石灰波爾多液則不及之。

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EFFECT OF CERESAN-LIME ON THE CONTROL OF RICE BLAST DISEASE

by

C. C. CHIEN

SUMMARY

This paper deals with the comparative studies on the effectiveness of Ceresan-lime (0.6% Ethyl Mercury Chloride, Hg. 0.25%) and Bordeaux mixture of 4–8 formula (4 g. of Copper sulphate, 8 g. of stone lime, and 1,000 cc of water) for the control of rice blast. According to laboratory and field trials which showed that Ceresan-lime dusting (30 kg per ha.) is more effective for controlling the disease than Bordeaux mixture (4000–5000 litre per ha.) spraying.

Leaf blast could be well controlled by three applications of Ceresan-lime before heading stage of rice. For the purpose of protecting the neck of ears and the node of culms become infested with the disease, then dusting should be held before and after heading stage.

農業研究 7(2):1-5 (1957)

施肥對于稻熱病之發生及藥劑撒佈效果之影響

第一報　稻苗試驗結果

徐水泉　簡錦忠

一、緒　　言

提高稻米單位面積產量之方法固多，然增加施肥是最速方法之一，但多施肥料易使稻作誘發病害，其中對稻熱病發生之影響為最大。關于施肥與稻熱病發生之關係的研究報告很多，堀氏[3](1898)報告氮肥施用量增多時，如燐肥及鉀肥亦同時增加，則可預防稻熱病之發生，但據村田氏等[10](1933)試驗報告，認為氮肥之施用量增多時，如燐肥或鉀肥亦同時增加，並不能阻止稻熱病之發生，故稻熱病之發生是受氮肥施用量之多寡所支配的。宮崎氏[9](1928)報告偏用氮肥對稻熱病發生之影響最大。又澤田氏[11](1939)報告氮肥增加時，每葉之稻熱病病斑數亦隨之增加，橋岡氏[14](1950)認為施用氮肥時，稻呈為感受性，不用氮肥時則呈有抵抗性的傾向，施用燐肥時呈微抵抗性，鉀肥稍呈抵抗性的傾向，臺灣省農業試驗所[13](1946～1947)報告鉀肥之施用對於稻熱病發生之影響不如氮肥之顯著，又分數次施用者則水稻被害略輕，產量亦高。逸見氏等[5](1941)亦認為氮肥施用量增加時，對於稻頸及成葉抵抗稻熱病之特性很明顯的減少。此等報告對於預防稻作病害之貢獻很大。稻作施肥量不同時對於稻熱病發生雖有差異，但對于藥劑防治效果之差異將有何影響則極少報告。鍬塚氏[7](1956)報告如氮肥施用量增加，同時應用西樂生石灰(Ceresan 石灰)預防者，其發病率與對照區比較則可減少約一半。著者等為明瞭施用三要素之種類，用量及其比率對于稻苗抵抗性之本質有何影響，又應用西樂生石灰(Ceresan-line)抑制寄生病原時，於不同施肥情形下所生育之稻苗在防除效果上是否有何差異，因而舉行此試驗。茲將初步試驗結果簡述於下：

二、材料及方法

(一)材料：供試稻種為臺中65號；供試藥劑為西樂生石灰【0.6% ethyl mercury chloride (Hg. 0.5%)，日本特殊農藥製造公司出品】；人工接種所用之稻熱病病原菌，係民國43年，由臺中65號品種之葉部病斑分離者，該病原菌於同年11月27日再移植於稻藁加蔗糖培養基培養，接種時將上述之培養基製成胞子懸浮液，每次接種時鏡檢懸浮液在每一視野中的胞子數為4～5個。

(二)方法：供用之土壤係取自前期作栽培水稻的跡地。當土壤搬入室內後，充分混和然後裝入小盒(50萬之一公頃)中，每盒裝土2公斤，每處理區施用不同肥料之成分及其用量列如表1。最後灌水使肥料和土壤充分混合後再行播種。供試稻種首先應用0.1%谷仁樂生(Granosan)溶液浸種消毒後用自來水洗滌，再浸水3天，斷水後放置於28°C定溫箱內萌芽。每盒播稻種100粒。

應用之肥料為硫酸錏(N20%)，過燐酸石灰($P_2O_5$19%)及硫酸鉀(K_2O 48%)等3種。撒佈藥劑處理分為①無撒佈區(對照)，②接種前撒佈藥劑區，③接種後撒佈藥劑區等。各區接種病原菌後保持適當濕度，逾24小時後再放置於玻璃室內，一星期後觀察各區之罹病情形。其結果如表2。

表1 每處理區之施肥成分及用量

號數	處理代號	處理名稱	每公頃施用成分（公斤）		
			N	P_2O_5	K_2O
1	000	無要素區	0	0	0
2	111	三要素少量區	40	30	20
3	222	三要素中量區	80	60	40
4	333	三要素多量區	120	90	60
5	444	三要素最多量區	160	120	80
6	022	無氮素區	0	60	40
7	122	氮少量區	40	60	40
8	322	氮多量區	120	60	40
9	422	氮最多量區	160	60	40
10	202	無燐區	80	0	40
11	212	燐少量區	80	30	40
12	232	燐多量區	80	90	40
13	220	無鉀區	80	60	0
14	221	鉀少量區	80	60	20
15	223	鉀多量區	80	60	60

三、試驗結果

本試驗係於民國45年10月23日播種；11月22, 23日下午舉行人工接種；接種前撒佈藥劑區於11月22日上午撒佈西樂生石灰，接種後撒佈藥劑區於11月24日下午撒佈西樂生石灰。12月3日調查記錄。玆將結果列於表2。

四、結果及討論

由本試驗結果可知氮，燐及鉀三要素之施用量同時增加時，稻熱病之發生是正比例增加的傾向，三要素施用中量時稻熱病即開始急激增加，每葉病斑數比無肥區約增加20倍。三要素少量區之每葉病斑數亦比無肥區增加約7倍，施用量最多區者多約30倍，如以三要素少量區之罹病率爲1時，中量區之每葉病斑數比少量區約增加3倍，多量區約4倍，最多量區約4.5倍之多。據澤田氏[11]報告肥料各要素配合量之增減及氮肥量增減之試驗區所示之結果，如施用量增加時則稻葉之長度及寬度成爲正比例增加，即葉之面積增大，其厚度亦較薄，葉稻熱病亦增劇，鈴木氏[12]（1933）認爲多施用氮肥區之稻葉表皮組織珪質化之程度比無氮肥區者爲小，宮崎氏[9]（1928）報告偏用氮肥區之罹病程度比施鉀肥區者約增多6倍，比施燐肥者約增多3倍。若燐肥及鉀肥之施用量不變，僅氮肥之施用量變更時，因無氮肥區每葉平均病斑數與無三要素施用區之差異不顯著，故燐肥及鉀肥似無助長此病的發生，但如氮肥的施用量漸增多時，其結果與上項之發生情形略同。就氮肥施用少量區比無加氮肥區之每葉平均病斑數約增多3倍，氮肥施用多量區約爲7.5倍，最多量區約爲9倍之多。橋岡氏[14]（1950）就肥料三要素與水稻稻熱病感受性之關係試驗結果，認爲施氮肥易誘感受性，如減少氮肥時則能增加抵抗性。澤田氏[11]（1939）報告氮肥施用量多時稻葉表皮細胞膜較薄，而且氣孔之數目亦增多其形狀亦較大，故病菌侵入稻葉組織的機會亦增多。逸見氏[5]（1941）報告增加氮肥時，不僅影響稻葉表皮厚膜細胞的數目，同時亦影響其化學的性質，特別是表皮壁的珪酸化，使稻減少對稻熱病的抵抗性。如氮肥及鉀肥之施用量不變，僅變更燐肥之施用量時，如不施燐

表2　施肥對于稻苗稻熱病之發生及藥劑撒佈之效果

處理別 / 調查項目 / 處理代號	無撒佈（對照）區						接種前撒佈藥劑區						接種後撒佈藥劑區					
	生育狀況			罹病程度			生育狀況			罹病程度			生育狀況			罹病程度		
	平均株高	平均一葉葉長	平均葉寬	每株平均病斑數	每葉平均病斑數	病斑平均長	平均株高	平均一葉葉長	平均葉寬	每株平均病斑數	每葉平均病斑數	病斑平均長	平均株高	平均一葉葉長	平均葉寬	每株平均病斑數	每葉平均病斑數	病斑平均長
	cm	cm	cm			cm	cm	cm	cm			cm	cm	cm	cm			cm
000	21.85	9.70	0.224	0.280	0.139	0.140	22.48	11.31	0.254	0.122	0.070	0.163	21.07	10.69	0.246	0.056	0.036	0.100
111	27.28	14.05	0.328	2.333	0.933	0.207	26.10	14.49	0.336	0.187	0.097	0.150	28.15	15.17	0.326	0.179	0.084	0.189
222	28.73	14.99	0.353	7.603	2.789	0.273	29.37	16.44	0.337	0.222	0.097	0.171	28.28	15.59	0.347	0.500	0.215	0.148
333	30.06	15.52	0.378	9.461	3.154	0.242	28.23	15.86	0.335	0.238	0.101	0.176	28.85	16.35	0.326	1.453	0.628	0.199
444	29.17	15.09	0.338	12.115	4.163	0.218	29.36	16.24	0.341	0.597	0.241	0.156	27.90	16.41	0.335	1.704	0.726	0.188
022	22.63	11.14	0.281	0.663	0.353	0.132	23.05	12.77	0.244	0.058	0.036	0.150	22.10	11.74	0.258	0.058	0.044	0.100
122	29.07	14.66	0.335	2.855	1.068	0.234	27.60	16.96	0.380	0.416	0.203	0.126	27.29	15.23	0.309	0.506	0.233	0.185
322	29.32	14.86	0.338	7.844	2.649	0.251	27.36	10.74	0.343	0.771	0.322	0.126	28.81	16.44	0.323	0.608	0.257	0.147
422	29.34	13.86	0.325	8.988	3.157	0.214	27.58	15.79	0.349	0.789	0.351	0.148	28.10	16.32	0.342	0.736	0.318	0.149
202	30.36	14.84	0.323	7.176	2.436	0.276	28.02	16.38	0.345	0.278	0.124	0.118	28.51	16.99	0.328	1.381	0.604	0.166
212	29.77	15.57	0.359	8.734	3.067	0.195	28.97	17.05	0.362	0.706	0.309	0.117	28.76	16.43	0.327	1.143	0.494	0.198
232	29.74	15.48	0.354	9.639	3.419	0.241	28.34	15.69	0.324	0.845	0.336	0.161	28.81	16.47	0.331	1.171	0.522	0.189
220	28.99	14.57	0.350	8.012	2.785	0.263	27.44	15.40	0.311	0.321	0.136	0.177	28.31	16.19	0.336	0.713	0.312	0.179
221	29.23	14.55	0.347	6.338	2.319	0.205	29.03	16.69	0.363	0.238	0.106	0.164	29.03	16.80	0.326	0.663	0.387	0.170
223	29.06	15.54	0.309	6.037	2.071	0.197	28.68	16.03	0.337	0.282	0.120	0.156	28.68	16.08	0.338	0.600	0.263	0.164

肥之試區及施用燐肥區兩相比較時，其每葉平均病斑數無顯著之差異，如以無燐肥區之每葉平均病斑數爲1時，燐肥施用少量區爲1.2，多量區爲1.4。關於此項結果據宮崎氏[9]（1928）報告燐肥對稻熱病發生程度尚無顯著之影響，故在預防及治病上須加考慮，澤田氏[11]（1936）報告燐肥的分量，如比氮肥及鉀肥的標準爲少時，則稻熱病的發生稍見增加，若過於多量時則與稻熱病之蔓延並無關係，但亦無制止稻熱病發生之效。橋岡氏[14]（1950）報告施用燐肥稍能增加稻株對稻熱病之抵抗性，由此可知燐肥對稻熱病發生之影響不大。再者鉀肥對稻熱病之發生情形比氮，燐兩種肥料之影響比較明顯，卽氮肥及燐肥之施用量不變，僅變更鉀肥之施用量者，就施用鉀肥區之每葉平均病斑數皆有減少的傾向，若以無加鉀肥區之每葉平均病斑數爲1時，施用少量區的病斑數約爲0.8，施用多量區約爲0.77。橋岡氏[14]（1950）報告施用鉀肥能增加稻之抵抗性，宮崎氏[9]（1928）報告鉀肥之施用量漸增加時，亦將阻止稻熱病之發生，又伊藤氏[4]等（1931）報告氮肥之施用量增多時，稻之角皮發達不良，燐肥亦顯示同樣的傾向，但多施用鉀肥者角皮之發達較爲良好。

據溫室內試驗所示，凡接種病原菌以前撒佈西樂生石灰作爲預防病害者，一般都比接種病原菌以後撒佈西樂生石灰作爲治療之防除效果爲佳。氮、燐及鉀三要素之施用量同時漸增多時，藥劑之預防效果尤爲明顯。施用中量，多量，最多量三要素區之預防效果，如以無藥劑撒佈區之每葉平均病斑數爲100時，預防區之每葉平均病斑數僅爲3～10，治療區爲7～20。燐肥及鉀肥施用量不變僅氮肥之施用量變更時，如以無藥劑撒佈區之每葉平均病斑數爲100時，其預防區之每葉平均病斑數爲10～20，治療區者爲10～21。氮肥及鉀肥施用量不變，僅燐肥之施用量變更時，如以無藥劑撒佈區之每葉平均病斑數爲100時，其預防區之病斑數爲5～10，治療區之病斑數爲15～25。氮肥及燐肥施用量不變，僅鉀肥之施用量變更時，如以無藥劑撒佈區之每葉平均病斑數爲100時，其預防區之病斑數僅爲4～5，治療區之病斑數爲11～16。

五、摘　　要

爲明瞭稻作施用三要素方法對于稻苗稻熱病發生以及其藥劑防治效果而舉行此試驗：

茲將其主要結果列舉如後：

（一）　當秧田施肥時，維持三要素之適當比率者，則可減輕稻苗稻熱病之發生，同時亦可增加稻熱病藥劑防治之效果。

（二）　對于稻熱病之發生，氮之影響最爲顯著，卽示正比例之傾向，而燐之影響不顯著，鉀則稍有抑制稻熱病發生之效果。

（三）　無論何種施肥情形下，稻熱病藥劑作爲預防者，都較作爲治療之效果爲佳。

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EFFECT OF FERTILIZERS ON THE OCCURRENCE OF BLAST DISEASE AND ITS CONTROL

(1) Experiment Results on Rice Nursery

by

Dr. S. C. HSU and C. C. CHIEN

SUMMARY

This expriment was carried out to obtain the relation between the application of fertilizers and the occurrence of rice blast or the effects of fungicidal control.

Some essential results are summarized as follows:

(1) The different level of three essential elements of fertilizers in suitable ratio could reduce the disease incidance and increase the fungicidal effects when they were applied to the rice nursery.

(2) The occurrence of blast disease were most pronounced with a increase in nitrogen level. Phosphorus did not show prominent influence upon the disease development, whereas potassium tended slightly to increase the seedlings resistant to blast infection.

(3) Under any different level of elements applied, the dusting with Ceresan-lime for the protection is better than eradication purpose.

168 中華農學會報 新第28期：39-48 (1959)

幾種殺菌劑對稻作三種病原菌之殺菌效力[1]

陳 其 昌[2] 簡 錦 忠[3]

一、前 言

稻爲臺灣最主要糧食作物，據王氏報告 (3)，其栽培面積佔耕地面積的 54.5%，估計年受病害之損失平年在 3～5%，就以 1957 年全年產量 180 萬公噸而言，因稻病害而損失之穀量達 54,000～90,000 公噸，因之防治稻作病害爲糧食作物生產之重要措施。現於本省稻作上應用殺菌劑防治病害已獲部份優良效果，但近年來隨科學之進步，新出品之農業用殺菌劑也逐日增多，其應用範圍亦廣。本試驗就主要稻作病害之病原菌分別供試，觀察幾種殺菌劑抑制病原發育之效力，冀有助稻作病害之防除。

在試驗進行時，蒙農試所長兼植物病理系主任徐水泉；洪技正章訓賜予工作上諸多方便，陳賀得、黃添福兩位先生協助，感激甚深，謹誌於此藉申謝悃。

二、試驗材料及方法

(一) **試驗材料** 供試病原菌，爲稻熱病菌、(*Piricularia oryzae* CAV.)稻徒長苗病菌 (*Gibberella Fujikuroi* (SAWADA) WR.) 及 稻葉鞘腐敗病菌 (*Acrocylindrium oryzae* SAWADA) 三種。供試藥劑計16種，使用濃度一律按其製品分爲 5,000倍、 10,000 倍及 20,000 倍三種。茲將供試藥劑的製造公司及其主要成分列於下表：

藥劑名 Fungicide	製造公司 Manufactory	主要成分 Chemical compound
Granosan	美國 E. I. Du Pont de Nemours & Co	5% Ethyl mercury phosphate
Granosan M	同上	7.7% Ethyl Mercury p-Toluene Sulfonanilide (Hg 3.2%)
Agrosan GN	英國 Plant Protection Ltd.	Organo-Mercurial salt, 1% mercury
Agrosan GN 5	同上	Organo-Mercurial salt, 5% mercury
Arasan	美國 E. I. Du Pont de Nemours & Co.	50% Thiram (Tetramethyl thiuramdisulfide)
Fermate	同上	76% Ferbam (Ferric Dimethyl dithiocarbamate)
Captan	美國 California Spray Chemical Co.	50% N-trichloromethyl mercapto-4-cyclohexene-1, 2-dicarboximide
Tuzet	德國 Bayer Co.	20% Methylarsin bisdimethyl dithiocarbamate 40% Tetoramthyl thiuram disulfide 20% Zinc dimethyl dithiocarbamate

1. 本試驗結果摘要業已 1958 年度中華農學會暨各農業學會年會時宣讀
2. 臺灣大學農學院教授兼臺灣省農業試驗所特約研究員
3. 臺灣省農業試驗所技士

藥劑名 Fungicide	製造公司 Manufactory	主要成分 Chemical compound
Fumiron Tablet	日本、北興化學工業公司	5% Phenyl mecuric p-toluene Sulfonic anilide and the other mercury compds
Fumiron	同上	6.53% Phenyl mecuric p-toluene Sulfonic anilide (Hg 2.5%)
Ruberon	日本、北興化學工業公司	4% Ethyl mercuric phosphate
Uspulun	日本、特殊農藥製造公司	4.2% Methoxyethyl-mercuric chloride
Microgin	日本、鹿兒島化學工業公司	5% Acetic phenyl mercury
Takeda Mer	日本、武田工業公司	10% Thiophthyl methan-disulphonic phenyl mercury
Dithane Z-78	美國Rohm & Haas Company	65% Zinc ethylene-bisdithiocarbamate
Tillex	瑞士 Sandoz Ltd.	Organo-mercury (Hg 1.5%)

（二） **試驗方法** 病原菌培養於馬鈴薯煎汁培養基（馬鈴薯 200公分、蔗糖20公分、洋菜20公分及蒸溜水 1,000 cc）內，置於 28°C 之定溫箱，經 7～14 日後作爲胞子浮懸液。又有培養糙米培養基上之胞子作爲浮懸液。另備馬鈴薯培養基，使其溶解後，冷却至 35 °C 左右時，加入上述胞子浮懸液，充分混合後注入培養皿(直徑 9 公分)內，每皿注入 15 cc， 另用濾紙剪爲小圓圈，其直徑爲 1 公分，經乾熱消毒後放入各藥劑稀釋溶液中浸漬10分鐘，取出後放於殺菌過的空培養皿內斜面陰乾，然後再放置於乾燥器內，經一晝夜以上，則取出圓圈濾紙一張置於上述含有胞子的培養皿之中央。操作完畢後，放置於28°C定溫箱經一定期間後觀察，按菌落與小紙圈間發生之抗拒距離，測定藥劑之制菌效力。

（三） **試驗進行日期** 稻熱病菌於1958年 5 月 1 日培養於糙米培養基，稻徒長苗病菌於1958年 4 月10日(第一重複)及 5 月25日(第二重複)培養於馬鈴薯培養基，稻葉鞘腐敗病菌於 1958 年 4 月 1 日(第一重複)及 4 月14日(第二重複)培養於馬鈴薯基。處理及觀察日期如下：

病原菌 Causal organisms	稻熱病菌 *Piricularia oryzae* CAV.		稻徒長苗病菌 *Gibberella fujikuroi* (SAW.) WR.		稻葉鞘腐敗病菌 *Acrocylindrium oryzae* SAW.	
重複 Replications	I	II	I	II	I	II
處理日期 Date treated	17/V	18/V	20/IV	1/V	7/IV	22/IV
觀察日期 Date observed 1	20/V	21/V	23/IV	3/V	9/IV	24/IV
觀察日期 Date observed 2	24/V	25/V	28/IV	9/V	14/IV	29/IV

三、實驗結果

（一） **各種殺菌劑之制菌效力** 本試驗每一重複供用培養皿五個，在處理後經一定時期後測定其抗拒狀況，其結果錄於表 1 及圖 1～3。

由上表及圖可知：對 *G. Fujikuroi* 之制菌力較强者有 Microgin, Takeda Mer, Fermate, Fumiron Tablet 等；對 *A. oryzae* 者有 Taked Mer, Fumiron Tablet, Fumiron 等；對 *P. oryzae* 者有 Agrosan GN5, Takeda Mer, Microgin, Fumiron Tablet 等。又各種殺菌劑之持久力，經先後兩次測定結果，因病原菌略有差異；但一般而論，以 Takeda Mer, Fumiron

表1. 各種殺菌劑對稻三種病原菌發育之制抑狀況

Table 1. Toxicity effects of 16 fungicides on the development of causal organisms (cm)

藥劑 Fungicide	稀釋倍數 Dilution	稻熱病菌 *Piricularia oryzae* CAV.		稻徒長苗病菌 *Gibberella fujikuroi* (Saw.) WR.		稻葉鞘腐敗病菌 *Acrocylindirium oryzae* SAW.	
		第1次調查 1st Inv.	第2次調查 2nd Inv.	第1次調查 1st Inv.	第2次調查 2nd Inv.	第1次調查 1st Inv.	第2次調查 2nd Inv.
Fumiron Tablet	5,000	3.083	1.457	2.758	2.067	3.484	3.184
	10,000	2.267	1.150	2.358	1.375	2.792	2.408
	20,000	2.000	1.125	1.725	0.884	2.508	2.034
Fumiron	5,000	3.675	1.880	2.859	1.983	3.384	3.284
	10,000	2.840	1.675	2.367	1.375	2.592	2.292
	20,000	1.990	0.660	1.350	0.417	2.250	1.767
Granosan	5,000	2.458	1.275	0.976	0.025	2.125	0.850
	10,000	1.450	0.000	0.725	0.000	1.859	0.717
	20,000	1.100	0.000	0.375	0.000	1.492	0.134
Granosan M	5,000	2.642	0.650	1.759	0.350	2.942	1.884
	10,000	1.783	0.000	0.500	0.000	1.452	0.000
	20,000	1.667	0.000	0.367	0.000	1.242	0.000
Agrosan GN	5,000	1.759	0.880	2.117	1.533	2.784	2.475
	10,000	1.525	0.650	0.900	0.642	1.934	0.933
	20,000	1.400	0.000	0.267	0.000	1.058	0.433
Agrosan GN5	5,000	3.600	1.808	3.225	2.300	4.167	3.892
	10,000	2.883	1.430	1.942	1.867	2.767	2.242
	20,000	2.700	1.250	1.434	0.759	1.975	1.150
Arasan	5,000	3.975	1.240	1.067	0.559	4.467	1.988
	10,000	3.041	0.000	0.442	0.000	2.733	0.067
	20,000	2.020	0.000	0.300	0.000	1.533	0.000
Ruberon	5,000	1.650	0.000	0.425	0.034	1.825	0.184
	10,000	1.425	0.000	0.067	0.000	0.909	0.000
	20,000	1.141	0.000	0.000	0.000	0.517	0.000
Uspulun	5,000	2.833	1.090	0.567	0.092	1.800	0.375
	10,000	2.000	0.766	0.000	0.000	0.934	0.167
	20,000	1.708	0.000	0.000	0.000	0.600	0.167
Microgin	5,000	2.917	1.258	2.108	1.184	2.909	2.517
	10,000	2.395	1.125	1.792	1.134	2.450	2.084
	20,000	1.920	0.940	1.333	0.542	1.750	1.000
Fermate	5,000	2.820	0.416	2.017	0.600	3.008	1.308
	10,000	2.190	0.000	1.292	0.242	2.392	0.384
	20,000	1.608	0.000	1.059	0.234	2.283	0.309
Tillex	5,000	2.342	0.625	0.650	0.000	1.275	0.000
	10,000	1.633	0.600	0.084	0.000	1.050	0.000
	20,000	1.110	0.550	0.000	0.000	0.367	0.000
Takeda Mer	5,000	4.110	2.375	3.059	2.084	3.309	2.892
	10,000	3.259	1.683	2.775	1.675	3.032	2.667
	20,000	2.908	1.408	1.884	1.000	2.484	2.092
Captan	5,000	1.117	0.000	1.317	0.000	2.250	0.533
	10,000	0.525	0.000	1.075	0.000	1.533	0.109
	20,000	0.125	0.000	0.975	0.000	1.217	0.000
Tuzet	5,000	3.800	1.180	2.150	0.817	4.333	1.934
	10,000	2.983	0.675	1.267	0.225	3.559	0.850
	20,000	2.400	0.525	1.208	0.192	2.800	0.634
Dithane Z-78	5,000	0.000	0.000	0.000	0.000	0.000	0.000
	10,000	0.000	0.000	0.000	0.000	0.000	0.000
	20,000	0.000	0.000	0.000	0.000	0.000	0.000
CK (對照)	—	0.000	0.000	0.000	0.000	0.000	0.000
	—	0.000	0.000	0.000	0.000	0.000	0.000
	—	0.000	0.000	0.000	0.000	0.000	0.000

備考：所表示數字是全制菌直徑減紙圈直徑之實數。

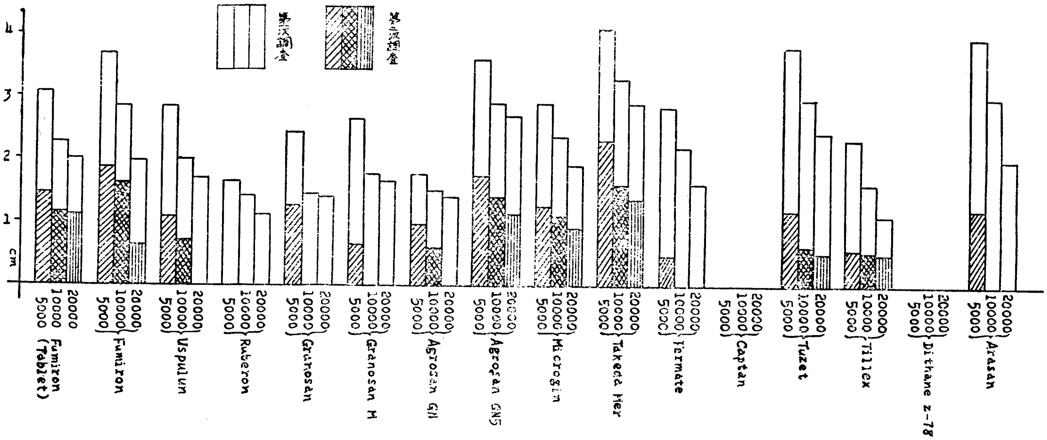


圖 1. 各種藥劑對 *Piricularia oryzae* 制菌圈之大小比較
Fig 1. The size of Clearing zone of *Piriculoria oryzae*

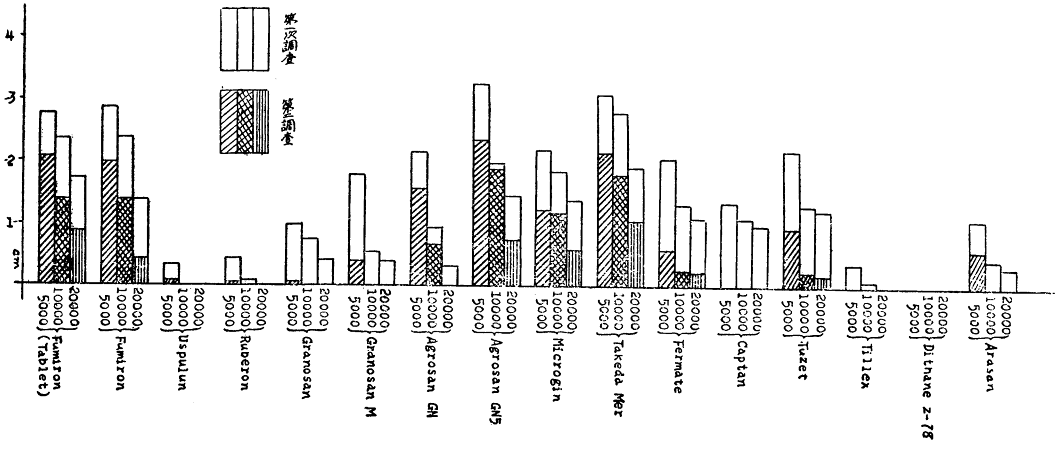


圖 2. 各種藥劑對 *Gibberella fujikuroi* 制菌圈之大小比較
Fig 2. The size of Clearing zone of *Gibberella fujikuroi*

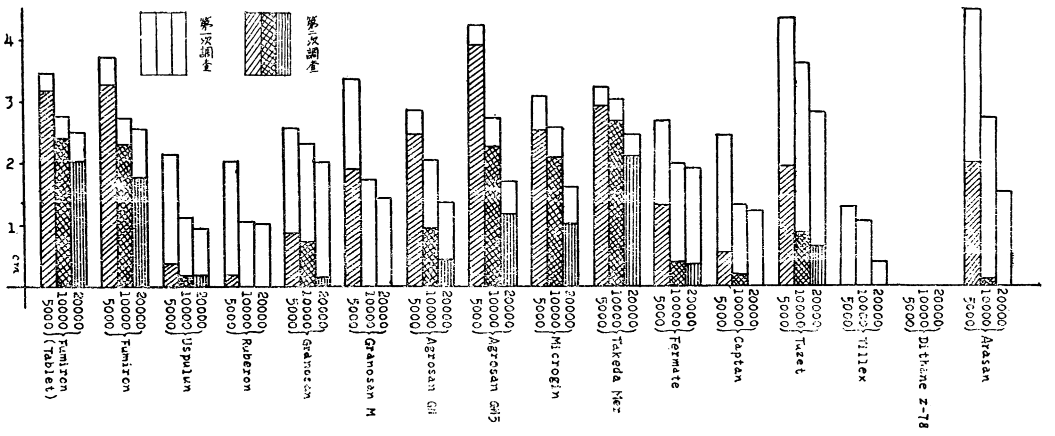


圖 3. 各種藥劑對 *Acrocylindrium oryzae* 制菌圈之大小比較
Fig 3. The size of Clearing zone of *Acrocylindrium oryzae*

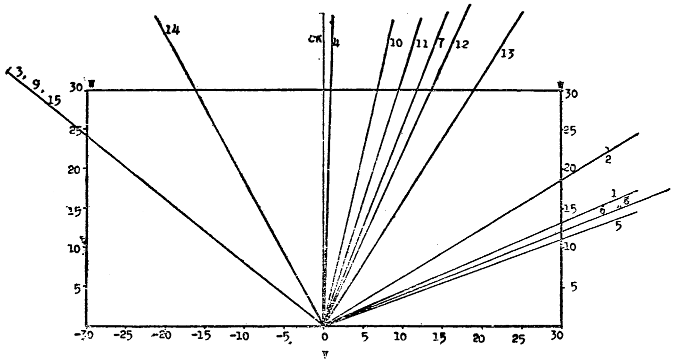
Tablet, Fumiron, Agrosan GN5, Microgin 等之制菌持久力較强。又各殺菌劑對菌之制抑力因濃度而異，就供試濃度範圍內所表示之制菌狀況而言，對不同病原菌之制抑狀況亦表示不同之反應。

（二） **由對數計算藥劑效力** 藥劑濃度之對數，在某種範圍內（本實驗供試濃度爲5,000～20,000倍），可以成立一直線的制菌效力。設一個的標準 (S) 爲 1 % (H)，其¼之濃度爲 0.25% (L)，所供試之藥劑 (U) 亦同一之濃度，但本實驗供試藥劑之最高濃度爲 5,000倍及其¼之 20,000倍。標準藥劑爲 Granosan。試驗結果由各種藥劑之制菌效力之圓圈直徑，各假定爲 S_H, S_L, U_H, U_L 由此可以算出成爲：

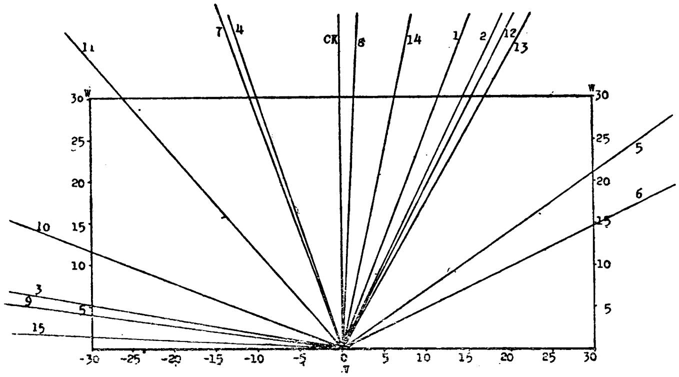
$$V=(U_H+U_L)-(S_H+S_L)$$

$$W=(U_H+S_H)-(U_L+S_L)$$

應用此公式，以表 1 所示之制菌直徑之數字，可以算出V及W價；由其價可以畫成直線（如圖 4～6），以表示其藥效。



第二次調查 Second investigation

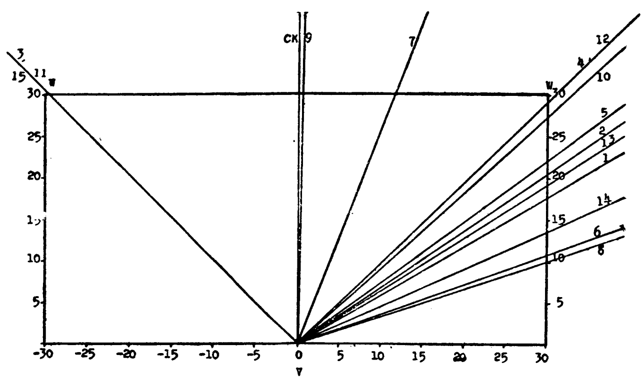


第一次調查 First investigation

圖 4. 對 *Piricularia Oryzae* 檢查圖

Fig 4. Indicative figure of effectiveness of fungicides for *Piricularia oryzae*

CK＝Granosan　1＝Fumiron Tablet　2＝Fumiron　3＝Captan　4＝Granosan M
5＝Agrosan GN 5　6＝Takeda Mer　7＝Uspulun　8＝Microgin　9＝Ruberon
10＝Agrosan GN　11＝Tillex　12＝Arasan　13＝Tuzet　14＝Fermate
15＝Dithane z-78



← 第二次調査
Second investigation

↓ 第一次調査
First investigation

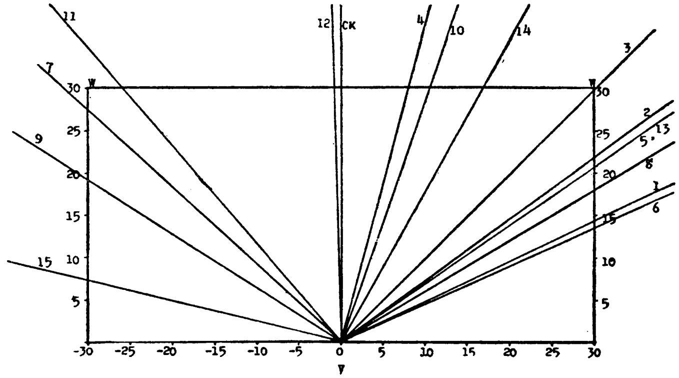
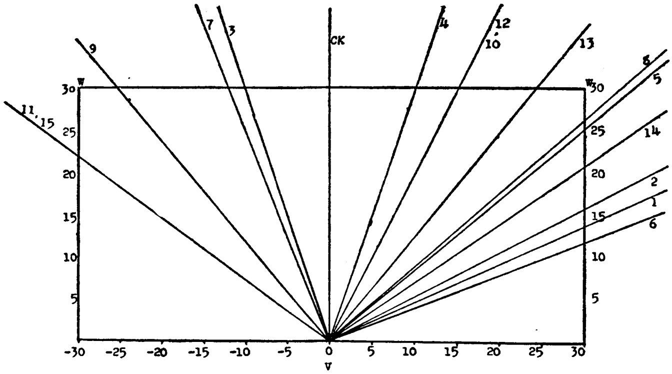


圖 5. *G. Fujikuroi* 之檢查圖

Fig 5. Indicative figure of effectiveness of fungicides for *G. fujikuroi*

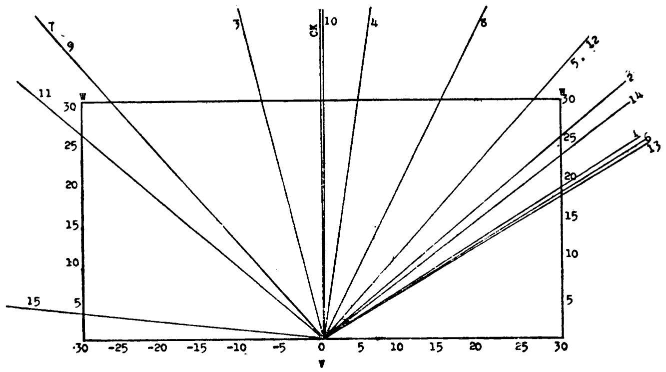


← 第二次調査
Second investigation

↓ 第一次調査
First investigation

圖 6. 對 *A. oryzae* 之檢查圖

Fig 6. Indicative figure of effectiveness of fungicides for *A. oryzae*



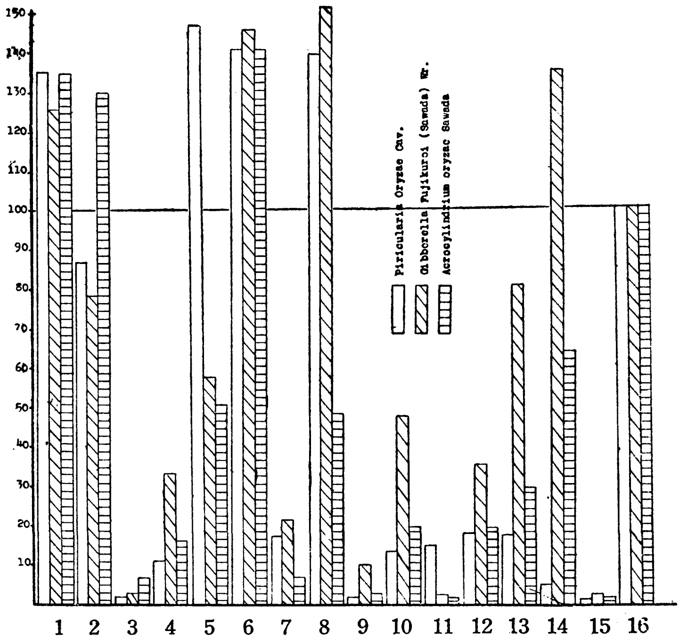


圖 7. 第1次測定之函數圖

Fig 7. Fungicidal funetion of 1st trial

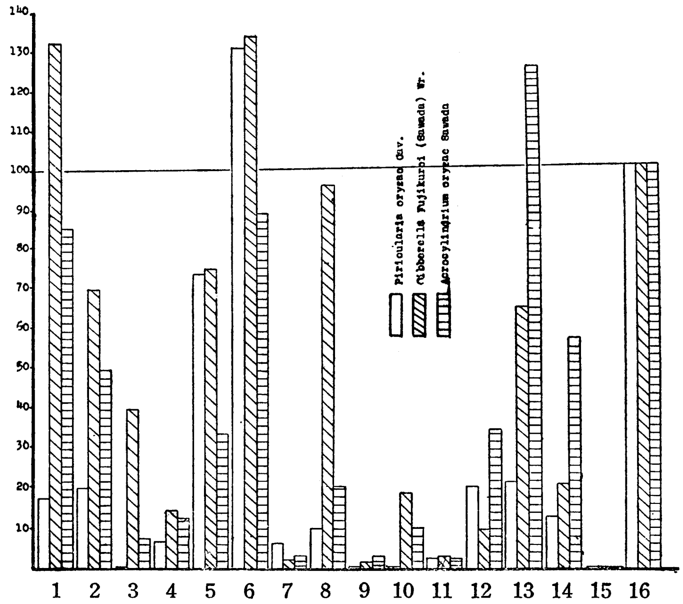


圖 8. 第2次測定之函數圖

Fig 8. Fungicidal function of 2nd trial

1. Fumiron Tablet	2. Fumiron	3. Captan	4. Granosan M
5. Agrosan GN 5	6. Takeda Mer	7. Uspulun	8. Microgin
9. Ruberon	10. Agrosan GN	11. Tillex	12. Arasan
13. Tuzet	14. Fermate	15. Dithane Z-78	16. Granosan

由圖4～6觀之，如以標準藥劑 Granosan 之制菌力爲0時，V價之直線在正方者其制菌力比標準藥劑較良；如在負方者則比標準藥劑較劣。各種殺菌劑由病原菌不同時，其制菌力略有差異；同時各種殺菌劑之維持時期亦有差。由第二次測定結果可知：其制菌力較强者，對 *P. oryzae* 有 Agrosan GN5, Takeda Mer, Microgin, Fumiron Tablet, Fumiron 等；對 *G. Fujikuroi* 者有 Microgin, Takeda Mer, Fermate, Fumiron Tablet, Tuzet, Fumiron, Agrosan GN5 等；對 *A. oryzae* 者有 Takeda Mer, Fumiron Tablet, Fumiron, Fermate, Agrosan GN5 等。

其次由上列之 V及W兩價，可以成立另一公式，即

$$\text{Log } \theta = \frac{V}{W} \times \text{Log } 4$$

θ 值是試驗藥劑與標準藥劑濃度之比率，此 θ 值在1.5以上及 0.5以下時，其檢定誤差爲大即不能採用，與標準液不能比較之。其結果錄於圖 7～8。

由上圖看之，1.0 以上者皆比標準藥劑爲良，以下者則較劣；但是0.5以下者，在此濃度者不宜應用，此並非無效之意，須俟提高其濃度再檢討之。

四、討 論 及 結 論

關於藥劑之效力試驗，大約可分爲抑制菌絲之發育，及阻止胞子之發芽，兩者間都有特長及其效果。但一般可形成胞子之病原菌者，在病害防治上應阻制胞子之發芽。對於抑制胞子發芽之試驗，方法如試管法 (Test tube method), 玻璃片法 (Slide method), Colochion method 或制菌圓圈法等。著者等應用此制菌圓圈法，就是 Cup method, Cap-plate method, Paper disk method 或稱爲阻止圓法。本法因爲使用凝固形的培養基之關係，可獲得胞子量的平均，而且可以在一定時間觀察之優點，即殺菌效力外亦可以觀察其維持力，又由其所測定的制菌圓圈直徑，應用 V, W 之價，作爲直線的檢定表 (Assay-chart) 以檢定其制菌效力及相關關係等最易了解，更由 V, W 價再應用 $\text{Log } \theta = \frac{V}{W} \times \text{Log } 4$ 之函數以求 θ 價，此 θ 價除可以表示制菌效果外，又可測知供試藥劑與標準藥劑之濃度比率，於是可以查出其使用濃度之範圍 (0.5～1.5)，在此範圍之外則不能與標準藥劑之比較。如 Captan, Uspulun, Ruberou, Agrosan GN, Tillex, Arasan, Dithane z-78 等，不能與標準藥劑比較之。本試驗所供試標準藥劑，爲現今在本省使用最普遍之 Granosan。因此本次實驗僅檢討各種殺菌劑對病原菌發育之制菌效力，做爲今後藥劑試驗之參考。

五、摘　　　要

本試驗係應用阻止圓方法測定探討幾種殺菌劑對稻三種病原菌之制抑力，其結果爲：

(一) 對 *Gibberella Fujikurai* (Saw.) Wr. 之效果：供試藥劑中制菌效力較强者，據第二次觀察結果爲 Microgin, Takeda Mer, Fermate, Fumiron Tablet, Tuzet, Fumiron, Agrosan GN5, Agrosan GN, Granosan M, Arasan 等，但 Captan, Tillex, Dithane z-78 等之效果較劣。

(二) 對 *Acrocylindrium oryzae* Sawada 之效果：供試藥劑中制菌效力較强者，據第二次觀察結果爲 Takeda Mer, Fumiron Tablet, Fumiron, Fermate, Agrosan GN5, Microgin, Tuzet, Agrosan GN, Arasan 等，其他殺菌劑如 Captan, Uspulun, Ruberon, Tillex, Dithane z-78 等之效果較劣。

(三) 對 *Piricularia oryzae* Cav. 之效果：供試藥劑中制菌效力較强者，據第二次觀察結果爲 Agrosan GN5, Takeda Mer, Microgin, Fumiron Tablet, Fumiron, Tuzet, Arasan,

Uspulun, Tillex, Agrosan GN 等，其他殺菌劑如 Fermate, Captan, Rubeson, Dithane z-78 等之效果較劣。

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Studies on the Effects of Some Fungicides on the Three Important Causal Fungi of Rice Diseases

by

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Summary

The present experiment deals with the fungicidal action of some fungicides upon three causal organisms of rice disease, namely, *Gibberella Fujikuroi* (SAW.) WR. *Acrocylindrium oryzae* SAWADA and *Piricularia oryzae* CAV., by means of a cup method. The resultant data so far obtained after 7-day incubation at 28°C are briefly summarized as follows. The most effective fungicide is given at first, then followed by a descending order named below.

1. The effects upon *Gibberella Fujikuroi* (SAW.) Wr. are: Microgin, Takeda Mer, Fermate, Fumiron tablet, Tuzet, Fumiron, Agrosan GN 5, Agrosan GN, Granosan M, Arasan etc. showed strong fungicidal action while other fungicides, i.e., Captan, Tillex, Dithane Z-78 showed poor effect on the tested organism.

2. The effets upon *Acrocylindrium oryzae* SAWADA are: Takeda Mer, Fumiron tablet, Fumiron, Fermate, Agrosan GN 5, Microgin, Tuzet, Agrosan GN, Arasan are found to be more effective among the chemicals so far tested. Poor fungicidal action was revealed by Captan, Uspulun, Ruberon, Tillex, Dithane Z-78 for the test organism studied.

3. The effects upon *Piricularia Oryzae* CAV. are: Agrosan GN 5, Takeda Mer, Microgin, Fumiron tablet, Fumiron, Tuzet, Arasan, Uspulun, Tillex, Agrosan GN are also effective for the causal organism in question, whereas Fermate, Captan, Ruberon and Dithane Z-78 were found to be less effective, so far as the experimental conditions studied are concerned.

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施肥對于稻熱病之發生及藥劑撒佈效果之影響

第二報 田間之施肥與稻熱病發生之關係

簡 錦 忠　徐 水 泉

一、緒　　言

關於施肥與稻熱病發生之關係的研究報告很多，如臺灣省農業試驗所[20] (1946~1947) 報告鉀肥之施用對於稻熱病發生之影響，不如氮肥之顯著，又分數次用者則水稻被病害之爲害略輕，產量亦高。據堀氏[4](1898)報告氮肥施用量增多時，如燐及鉀肥亦同時增加，則可預防稻熱病之發生，但據村田氏等[13](1933) 試驗報告，認爲氮肥之施用量增多時，如燐或鉀肥亦同時增加，並不能阻止稻熱病之發生，故稻熱病之發生是受氮肥施用量之多寡所支配的。宮崎氏[12](1928)，澤田氏[16](1939)等報告亦認爲偏用或增加氮肥時，對稻熱病之影響頗大，橋岡氏[6](1950)認爲施用氮肥時，稻呈爲感受性，不用氮肥時則呈有抵抗性的傾向，施用燐肥時呈微抵抗性，鉀肥稍呈抵抗性的傾向。岡本氏[14](1950)報告缺乏燐肥時，稻熱病之發生爲多，但施用量多稻所需量以上者則無抑制發病之效果，又燐之效果在氮肥多用時較爲顯著。著者等[3](1958)曾於室內檢討三要素對于稻熱病發生以及其藥劑防治效果，結果獲知維持三要素之適當比率者，則可減輕稻苗稻熱病之發生，同時亦可增加稻熱病被藥劑防治之效果，但氮肥之影響最爲顯著，即示正比例之傾向，而燐之影響不顯著，鉀則稍有抑制稻熱病發生之效果，又無論何種施肥情形下，藥劑對稻熱病作爲預防者，皆較作爲治療之效果爲佳。故本試驗係按其結果在田間實際地，於不同施肥情形下所生育之稻作，對稻病害發生之影響是否有何差異，而舉行本試驗。玆將所得結果簡述於下：

二、材料及方法

1. 材料：供試稻種爲臺中65號及臺中特 6 號；供試肥料爲硫酸錏 (N 20%)，過燐酸石灰(P_2O_5 19%)及硫酸鉀(K_2O 48%)等三種。
2. 方法：供試稻種在播種前首先應用 0.1 %谷仁樂生 (Granosan) 水溶液浸種消毒後用自來水洗滌，再浸水 3 天，斷水後放置於 28°C 定溫箱內萌芽，秧苗時期育苗係無肥栽育。田間係應用隨機排列，各處理二重複。每小區爲 18m²，又各小區內一半栽植臺中65號，其除即栽植臺中特 6 號。田間管理與常法相同，但追肥僅第二次除草時期施用。於田間無舉行人工接種病原，則任其自然發生，在適當時期調查各小區之發病狀況。各處理區之施肥量及區別如表一：

表一　各處理區之施肥成分及用量 (公斤/公頃)

試驗區代號	處理代號	基肥			追肥		計		
		N	P_2O_5	K_2O	N	K_2O	N	P_2O_5	K_2O
1	111	40	60	40	40	—	80	60	40
2	110	40	60	—	40	—	80	60	—

3	222	80	120	80	80	—	160	120	80
4	222	80	120	40	80	40	160	120	80
5	211	80	60	40	80	—	160	60	40
6	212	80	60	40	80	40	160	60	80
7	111.5	40	60	60	40	—	80	60	60
8	112	40	60	60	40	20	80	60	80

三、試驗結果

本試驗係民國 47, 48年度第一期作舉行，47年度於 3 月 6 日播種， 3 月31日插秧，兩期作之基肥皆於插秧前一日施用，追肥於 4 月21日施用。於 7 月13日收穫。48年度於 3 月 4 日播種 3 月31日插秧，追肥於 4 月21日施用， 7 月25日收穫，於收穫前調査各處理區之生育狀況及發病程度。茲將結果列於下列諸表：

表二　四十七年度試驗結果

代號	區別	品種名	株高（公分）	穗數	稻熱病發病狀況			紋枯病發病莖率(%)	產量（公分/坪）		
					葉稻熱病		穗稻熱病(%)		乾燥重	精選重	粃
					每葉病斑數	病斑長徑(公分)					
1	111	臺中65號	96.31	17.03	0.305	0.910	0.79	13.43	1,070.0	1,037.5	32.5
		臺中特6號	83.70	19.90	0.298	0.994	0.81	15.18	1,005.0	982.5	22.5
2	110	臺中65號	91.42	16.16	0.305	1.446	0.82	14.68	1,072.5	1,047.5	25.0
		臺中特6號	80.36	19.57	0.303	0.500	1.50	14.18	935.0	905.0	30.0
3	222	臺中65號	102.18	17.61	0.365	1.045	1.92	24.49	995.0	962.5	32.5
		臺中特6號	89.00	21.35	0.680	1.391	1.86	23.56	920.0	837.5	82.5
4	222	臺中65號	102.40	19.00	0.356	1.020	0.81	20.93	1,067.5	1,022.5	45.0
		臺中特6號	92.11	21.87	0.307	1.005	1.50	18.25	1,080.0	940.0	140.0
5	211	臺中65號	98.40	19.18	0.956	1.431	1.73	30.12	1,012.5	982.5	30.0
		臺中特6號	87.23	20.90	1.020	1.400	1.49	28.43	975.0	932.5	42.5
6	212	臺中65號	101.65	18.50	0.349	1.044	0.98	26.87	1,020.0	985.0	35.0
		臺中特6號	91.61	23.05	0.335	1.013	1.08	25.12	1,010.0	937.5	72.5
7	111.5	臺中65號	96.11	15.11	0.258	0.905	0.80	10.00	1,070.0	1,050.0	20.0
		臺中特6號	82.87	18.40	0.209	1.005	0.72	16.12	1,030.0	997.5	32.5
8	112	臺中65號	95.05	13.78	0.235	0.957	0.65	12.93	1,085.0	1,070.0	15.0
		臺中特6號	83.25	18.73	0.204	0.985	0.62	12.93	1,082.5	1,052.5	30.0

表三　產量變量分析表

變因	自由度	平方和	均方和	F
重複	1	3,250.78	3,250.78	1.431
處理	7	66,267.97	9,466.85	4.166*
品種	1	40,969.53	40,969.53	18.028**
處理×品種	7	12,611.72	1,801.67	

機　　差	15	34,086.72	2,272.47	
總　　數	31	157,186.72		

*＝差異顯著標誌，**＝差異極顯著標誌

表四　47年度各區穀粒產量差異比較

處理代號	產　　量							
8	1,061							
7	1,024	37						
1	1,010	51	14					
4	981	80	43	29				
2	976	85	48	34	5			
6	961	100	63	49	20	15		
5	958	103	66	52	23	18	3	
3	900	161	124	110	81	76	61	58

~~~~差異顯著所需差數＝101.44，——差異極顯著所需差數＝139.78

表五　47年度品種穀粒產量差異比較

品　　種	產　　量	
臺 中 65 號	1,019	
臺 中 特 6 號	948	71**

**＝差異極顯著標誌

表六　四十八年度試驗結果

代號	區別	品種	株高（公分）	穗數	穗稻熱病被害率（%）	葉鞘腐敗病被害率（%）	紋枯病被害率（%）	產量（公分/坪） 乾燥重	精選重	粃
1	111	臺中65號	94.30	14.80	0.62	0.07	6.00	1,110.0	1,082.5	27.5
		臺中特6號	94.33	14.13	0.67	0.07	7.20	957.5	902.5	55.0
2	110	臺中65號	96.13	14.38	0.82	0.19	9.26	1,142.5	1,110.0	32.5
		臺中特6號	87.53	16.98	0.93	0.17	8.69	960.0	900.0	60.0
3	222	臺中65號	102.38	16.20	1.88	0.79	26.94	1,045.0	967.5	77.5
		臺中特6號	95.58	15.08	1.38	0.94	21.07	700.0	590.0	110.0
4	222	臺中65號	100.28	17.05	0.69	0.07	20.09	1,127.5	1,075.0	52.5
		臺中特6號	94.98	16.60	0.96	0.38	28.44	822.5	722.5	100.0
5	211	臺中65號	99.75	16.55	1.44	0.38	27.32	1,115.0	1,070.0	45.0
		臺中特6號	94.25	19.03	1.44	0.82	27.07	1,015.0	922.5	92.5
6	112	臺中65號	98.78	16.65	0.88	0.10	20.44	992.0	930.0	62.0
		臺中特6號	98.23	16.65	0.51	0.19	24.00	815.0	665.0	150.0
7	111.5	臺中65號	98.88	15.28	0.69	0.10	6.19	1,212.5	1,185.0	27.5
		臺中特6號	93.35	15.18	0.76	0.28	8.38	955.0	872.5	82.5
8	112	臺中65號	99.75	13.63	0.60	0.09	4.19	1,162.5	1,137.5	25.0
		臺中特6號	93.08	15.33	0.69	0.11	4.75	887.5	812.5	75.0
~~~~

表七　產量變量分析表

變　　因	自由度	平方和	均方和	F
重　　複	1	13,050.0	13,050.0	31.078
處　　理	7	267,743.8	38,247.1	91.086**
品　　種	1	588,459.4	588,459.4	1,401.40**
處理×品種	7	50,065.8	7,152.3	17.0**
機　　差	15	6,299.8	419.9	
總　　數	31	925,617.8		

**＝差異極顯著標誌

表八　48年度各區穀粒產量差異比較

處理代數	產　量							
8	1,225							
7	1,029	196						
2	1,005	220	24					
5	996	229	33	9				
1	993	232	36	12	3			
4	899	326	130	106	97	94		
6	798	427	231	207	198	195	101	
3	779	446	250	226	217	214	120	19

～～差異顯著所需差數＝22.38，——差異極顯著所需差數＝60.39

表九　48年度品種穀粒產量差異比較

品　種	產　量	
臺中65號	1,070	
臺中特6號	798	262**

**＝差異極顯著標誌

表十　47, 48年度產量分析表

變　　因	自由度	平方和	均方和	F
重　　複	1	53,704.3	53,704.3	6.059
處　　理	7	373,915.25	53,416.46	6.026**
品　　種	1	669,332.4	669,332.4	27.980**
處理×品種	7	22,773.85	3,453.41	
機　　差	15	132,983.2	8,865.5	
總　　數	31	1,262,709.0		

**＝差異極顯著標誌

表十一　47, 48年度各區穀粒產量差異比較

處理代號	產　　量							
8	1,143							
7	1,027	116						
1	1,002	141	25					
2	991	152	36	11				
5	974	169	53	28	17			
4	940	203	87	62	51	34		
6	879	264	148	123	112	95	61	
3	839	304	188	163	152	135	101	40

〰〰差異顯著所需差數＝163.66，——差異極顯著所需差數＝226.23

表十二　品種穀粒產量差異比較

品　　種	產　　量	
臺 中 65 號	1,044	
臺 中 特 6 號	904	140**

**＝差異極顯著標誌

四、結 果 及 討 論

由本試驗結果得知，氮肥之施用量如增加2倍時，葉稻熱病，穗稻熱病之發病率亦成爲正比例增加，其中如三要素之施用量同時增加2倍，例氮肥施用量之一半和另二要素皆爲基肥氮肥之一半做爲追肥區，比同量之鉀肥之一半爲基肥，一半爲追肥區之發病程度稍稍爲高。氮肥施2倍，燐及鉀肥施普通量時較三要素皆施2倍區之發病程度爲高，但鉀肥施2倍，分別於基，追肥施用者較前者較佳。又三要素之施用量爲普通量時較缺鉀肥區之葉稻熱病發病程度稍少，但氮、燐爲普通量，鉀肥爲1.5倍量或2倍量（分別於基，追肥施用）區之發病程度在全試驗區內最少。據澤田氏[16]報告，肥料各要素配合量之增減及氮肥量增減之試驗區所示之結果，如施用量增加時則稻葉之長度及寬度成爲正比例，其厚度反之較薄，葉稻熱病亦增劇，又橋岡氏[6]（1950）就肥料三要素與水稻稻熱病感受性之關係試驗結果，認爲施氮肥易誘感受性，如減少氮肥時則能增加抵抗性。島田氏等[18]（1954）報告增加氮肥之施用量而且減少鉀肥之施用量者，罹稻胡麻葉枯病之程度較多，又施2倍氮肥而無施鉀肥區之罹病程度更顯著。據本試驗結果亦增加氮肥，無增加鉀肥區之每葉稻熱病病斑最多，較氮肥普通量，鉀肥2倍量區之病斑數多達4～5倍。又病斑之長度亦因氮肥施用量增多而成爲正比例，則氮肥2倍，燐、鉀肥普通量時病斑之長徑達1.4公分以上（47年度）。此項據澤田[16]氏認爲氮肥施用量增加時，稻葉表皮細胞膜較薄，而且氣孔之數目亦增多，其形狀亦較大，故病原菌侵入稻葉組織的機會亦增多。逸見氏[5]（1941）報告增加氮肥時，不僅影響稻葉表皮厚膜細胞的數目，同時亦影響化學的性質，特別是表皮壁的珪酸化，使稻減少對稻熱病的抵抗性。

至於各區對稻紋枯病之影響，略與葉稻熱病之影響相同，即氮肥施用量在2倍，無論燐、鉀肥2倍或普通量，其發病莖率都在20%以上，但三要素施用量爲普通量或增加鉀肥者，其發病莖率在10～16%（47年度）或10%以下（48年度）。關於此項據臺灣省農業試驗所[20]（1947）報告，稻紋枯病之發生與稻熱病同，即氮肥施用量與被害率平行的增加，單用或無要素區之被害率較少，又據鶴田

氏[19] (1916) 認爲被稻紋枯病爲害稻較易倒伏，其爲害激甚時可減收 40～50%，如施多氮肥，未熟堆肥或遲延追肥時紋枯病之發生爲多。池野氏等[9] (1953) 經試驗結果，稻紋枯病之發病程度於無鉀區，氮多區爲多，尾崎氏等[15] (1953) 報告稻紋枯病與肥料之關係，如缺乏氮、燐區或多施鉀區之被害率爲輕。

再者各處理區穀粒產量比較者，氮、燐普通量，鉀肥 2 倍其施用時期分爲氮、鉀各一半及燐肥做爲基肥，氮、鉀各一半於第 2 次除草施用者最高，其次爲氮及燐普通量鉀肥 1.5 倍量區，產量最差爲三要素皆爲 2 倍區，此種現狀在兩年度之結果略相同，但氮肥施用量增多，而且鉀肥同時增多時其產量亦較差。關於此項據張氏等[1] (1953) 報告，於臺灣水稻之產量，氮肥對於水稻之增產率第 1 期稻作平均爲80%，第 2 期爲35%，燐肥於第 1 期作爲 5 %，第 2 期作爲 1 %，鉀肥對於第 1 期作平均爲 4 %，第 2 期作爲 9 %。又曾氏[21] (1959) 認爲臺灣水稻鉀肥對稻穀之增產，平均在 5 %。又據鳥居氏[22] (1959) 報告在熱帶環境下，施鉀肥時因 Eh 之提高，其營養體之生產力減弱，促進抽穗結實，因此 N 與 K 之間需要有適發平衡存在，超過其平衡量的鉀，更會使成熟期提早。不過本試驗欲明瞭施肥與病害之關係，故其栽植時期較一般較遲，又在稻生育期間斷續灌水，使土壤乾濕不均，以使其易罹病害之發生，故對稻穀之產量之影響，被病害發生之多寡有密切之關係，但按著者等[3] (1958) 於室內試驗所得結果與本次在田間之結果略獲相同，至於稻生育期間於何時施肥及施肥方法亦可能會影響稻熱病之發生，關於此項須待將來之探討。

五、摘　　要

爲明瞭稻作於田間施用三要素之用量及施肥時期對于稻病害發生之關係，而舉行此試驗。玆將其主要結果列擧如後：

1. 如氮肥之施用量增加 2 倍時，無論燐及鉀肥同時增加或較少者，葉、穗稻熱病之發生最多。
2. 氮及燐肥爲普通量，而且鉀肥之施用量增加1.5倍或 2 倍時，病害之發生程度較輕。
3. 稻紋枯病之發病狀況與稻熱病之罹病狀況略同。
4. 三要素中對病害之發生最有密切之關係者爲氮肥。
5. 稻穀之產量與病害之發生程度成爲反比例。即無論稻熱病、紋枯病或葉鞘腐敗病之發生多時，其產量爲低。
6. 增加鉀肥，而且一半爲基肥，其餘爲追肥時無論對病害或產量之影響皆最佳。

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EFFECT OF FERTILIZERS ON THE OCCURRENCE OF RICE BLAST DISEASE AND ITS CONTROL

(2) Results of paddy field experiment

by

C. C. CHIEN & S. C. HSU

SUMMARY

The relation between the prevalence of rice blast (Piricularia oryzae) disease, and rates and time of N.P.K. fertilizer application were studied. The result indicated that the degree of leaf and neck blast disease infections were greatly increased, despite of simultaneous increase of decrease of phosphorus and potash fertiliers. The blast disease infection was lighter when the N.P.K. fectilizers were applied at the rates of 80, 60, 60 or 80 kilograms per hactre respectively. With regard to the rates of fertilizers application the prevalence of sheath and leaf spots was similar to that of blast disease. Among the three elements applied, nitrogen fertilizer tended apparently to induce the disease infections. The grain yield was greatly reduced as the result of infections with blast, leaf and sheath spots, and sheath rot diseases, howevee, the grain yield was freatly improved when the total amount of potash was increased, and a half of which was used as basic manure and the other half was used as top-dressing.

稻熱病病原生理型之研究

洪 章 訓　簡 錦 忠　林 淑 媛

一、緒　　言

在減少植物病害之對策中，最有效爲預防，預防中最合乎經濟原則者爲育成抗病性品種及其栽培。但於育成抵抗性品種之過程中，首先須明瞭抗病性之本質，再確立抗病性之檢定法。

本省關於稻熱病之研究，自幾年前開始，但一般認爲較爲抗稻熱病之稻品種，近年來在各地栽培後，其抗病情形頗有差異，此中原因究係受各地區及季節氣候因子影響，抑或由稻熱病病原生理之變異，對此點即稻熱病病原菌之系統研究尚缺詳細之探討，實爲從事稻抗病育種工作之先決問題。

本試驗欲探求稻熱病病原是否有生理型存在，種類若干，及分佈情形如何，俾能配合稻作育種及品種推廣。

茲將今年度所得結果列述如下，又此項試驗之經費承蒙中國農村復興委員會補助，得以完成，特此併致謝忱。

二、材料及方法

1. 1959年自臺中、高雄、嘉義、臺北(宜蘭)等地農業改良場所試驗田栽培之水稻品種及本所附近農田雜草，分離培養之稻熱病病菌經單胞分離後，所得菌號共155種，以供試驗。

2. 生理試驗：包括不同溫度(13°, 19°, 25°, 28°, 34°C)，不同酸鹼度（pH 4.5, 5.5, 6.5, 7.5, 8.5）及不同營養（糙米、玉米、高粱、Czapek等培養基），供試菌號選自155菌號在糙米培養基，28°C培養二週呈現不同菌落形態之菌號。

3. 接種試驗：

a. 根據1957年全省性田間觀察及本系人工接種稻熱病菌，品種間反應結果，選出16種水稻品種做爲判別品種。(見後)

b. 在溫室內應用鉛盤培育稻苗，每盤播16品種，利用重氮旱栽，每盤施用硫酸錏水溶液 2 %，500 cc 二次，苗生長約達15公分時，舉行人工接種。

c. 各菌號之病原菌培養於稻穗培養基(500 cc裝三角瓶，稻穗60 g，蔗糖液 2 %20 cc)設換氣裝置，以增殖分生孢子，經 9～10天作成孢子懸浮液，各菌號間之供接種孢子量盡量調製一致，每 4 平方英尺 800 萬～1,000 萬/600 cc。

d. 於暗室內行噴霧接種，每盤罩以玻璃膠帶隔離之，每處理三重覆，前後舉行三次，接種後保持12小時黑暗，並維持相對濕度在95%以上，接種後第 4 天開始調查各品種之感病反應，繼續觀察至第10天，觀察感病反應之標準如下：

(1) S (Susceptible)＝感病性：病斑大型紡綞形或類似的形狀，在病斑中部呈灰白色，內緣呈褐色，外緣呈黃色或黃褐色，但如病斑屬小型其全部色澤呈灰色（即急性病斑）亦屬本型。

(2) M (Intermediate)＝中間性：各種形狀的病斑，該斑僅呈褐色，中央部無或稍帶灰白色。

(3) R (Resistant)＝抗病性：小斑點或小病斑，呈褐色乃至帶黑褐色。

(4) I (No lesion)＝無感病反應：無病斑。

三、試驗成績

1. 不同溫度與稻熱病病原菌之生長比較：

本試驗供試之病原均使用糙米煎汁培養基培養；其配合量爲糙米 200 g，洋菜17g，蔗糖20g，蒸餾水 1000 cc，溫度調節分爲 13, 19, 25, 28 及 34°C等五級，借用臺大植物病理系冷藏室舉行。供試菌種爲 886 菌號採自嘉義分所，自臺中系比33號所分離，891 及 288 菌號採自同所，自 Custug-ulcule 所分離，529 及 1124 菌號採自臺中(東勢)，自光復 1 號所分離， K67 及 111 採自高雄（萬巒），自嘉農 242 號所分離，草 7 菌號於本所自雜草分離所得之病原。每菌號三個重覆，經過十天之培養，然後調查其生育情形，前後三次其平均結果列於表一。

表一　溫度與病原菌生育情形之比較

菌號 \ 生育情形 \ 溫度			13°C	19°C	25°C	28°C	34°C
891	菌落	直徑	(mm) 50.3	69.2	75.0	84.0	11.5
		色澤	白色氣生菌絲生長細密	同左	同左	白色氣生菌絲較稀疏	同左
529	菌落	直徑	(mm) 40.5	65.0	73.5	80.0	10.0
		色澤	灰綠色	同左	同左	同左	同左
886	菌落	直徑	(mm) 42.0	60.5	69.5	84.5	10.7
		色澤	墨綠色氣生菌絲從中央起成放射形生長	同左	同左	同左	同左
1124	菌落	直徑	(mm) 45.3	63.1	68.9	81.5	10.9
		色澤	灰綠色外圍有一圈白色菌絲寬 5 mm	同左	同左	同左	同左
288	菌落	直徑	(mm) 44.5	63.3	69.5	83.5	10.9
		色澤	棕灰色氣生菌絲絨毛狀高 1～1.5 mm	同左	同左	同左	同左
K 67	菌落	直徑	(mm) 43.5	56.9	65.5	82.5	10.9
		色澤	墨綠色	同左	同左	同左	同左
111	菌落	直徑	(mm) 40.0	56.5	65.5	79.5	9.8
		色澤	墨綠色外圍爲一圈白色菌絲寬10 mm	同左	同左	同左	同左
草 7	菌落	直徑	(mm) 29.9	46.3	51.0	58.4	5.1
		色澤	中央呈草綠色	同左	同左	同左	同左

據表一可知各供試菌號均於28°C下生長最優良，高溫34°C或於低溫13°C下之生長均較慢，尤以34°C 下生長最慢 。供試7種菌號中以891菌號在各種溫度下之生長速度都較快，111菌號生長較慢，其他菌號之差異不大。又觀察菌落之色澤 ，891菌號呈白色，於25°C以下溫度其氣生菌絲之生長爲細密，但28°C以上者氣生菌絲較爲稀疏，529菌號之菌落色澤無論任何溫度下均呈灰綠色，886, K67及111菌號之菌落呈墨綠色，886菌號之氣生菌絲從中央起成放射形生長，111菌號之菌落外圍呈一圈白色菌絲，1124菌號呈灰綠色，菌落邊緣有一圈白色菌絲，288菌號呈棕灰色，氣生菌絲呈絨毛狀。

2. 不同 pH 之培養基與稻熱病病原菌之生長比較：

應用 Czapek 氏培養基，pH 之等級分爲 4.5, 5.5, 6.5, 7.5 及 8.5 等五階級，供試菌號與一項相同。在28°C定溫箱經培養十天後觀察其生育情形，每菌號三重覆，前後三次之平均結果列於表二。

表二　培養基 pH 值與生育情形之比較

菌號	生育情形		pH 值 4.5	5.5	6.5	7.5	8.5
891	菌落	直徑	(mm) 62×60	58×60	56×58	55×53	50
		色澤	灰白色菌絲生長細密	同 左	同 左	同左但菌絲較稀且粗	同左但氣生菌絲很粗
529	菌落	直徑	(mm) 58	56	53	55×53	45
		色澤	灰綠色	同 左	同 左	同左但菌絲生長較粗	同 左
886	菌落	直徑	(mm) 40×45	48×45	53	50×53	42×40
		色澤	墨綠色中央色深外圍菌絲稀疏	同 左	同左但外圍菌絲生長粗	同 左	同左菌絲生長很粗
1124	直徑	色澤	(mm) 45	50×52	50	50	50
		同左	灰綠色外圍有一圈白色透明菌絲寬 50mm	同 左	同 左	同 左	同左但菌絲較粗
288	菌落	直徑	(mm) 50×52	56×60	65	50×55	50
		色澤	棕灰色氣生菌絲，絨毛密生	同 左	同 左	同 左	同 左
K 67	菌落	直徑	(mm) 57×58	56	56×58	55	50
		色澤	墨綠色	同 左	同 左	同左但菌絲生長很粗	同 左
111	菌落	直徑	(mm) 58	45	53×54	40	45
		色澤	墨綠色邊緣不完整，外圍有一圈透明白色菌絲	同 左	同 左	同左但氣生菌絲生長較粗	同左但氣生菌絲生長漸粗

草 7	菌落	直徑 (mm)	55×60	45	40	35	20×25
		色澤	墨綠色外圍淺但菌絲生長細密	同　左	同左但外圍菌絲生長漸粗	同　左	同左但菌絲生長很粗

按表二，得知 pH 值低時，各菌號之菌絲生長細密，自 pH 6.5 以上各處理區之菌絲漸趨稀而粗。pH 8.5 時各菌號生長緩慢，尤以草 7 菌號爲明顯。又在 pH 4.5 時生長最佳，pH 值漸高其生長不良之菌號有 891, 529, K67, 111, 草 7 等，886 及 288 菌號在 pH 值 6.5 時，1,124 菌號在 pH 值 5.5 時生育較良。

3. 不同營養物質之培養基與稻熱病病原菌之生長比較：

供試培養基種類有糙米煎汁培養基（糙米 200 g；洋菜 17 g；蔗糖 20 g；蒸餾水 1,000cc），高粱煎汁培養基（高粱 200 g；洋菜 17 g；蔗糖 20 g；蒸餾水 1,000 cc），玉米煎汁培養基（玉米 200 g；洋菜 17 g；蔗糖 20 g；蒸餾水 1,000 cc）及 Czapek 氏培養基等四種。每菌號三重覆培養於 28 °C定溫箱，經二週(14天)後觀察其生長情形前後三次，其平均結果列於表三。

表三　不同營養培養基與病原菌生長比較

菌號	生長情形	糙　米	高　粱	玉米粉	Czapek
891	菌落直徑 (mm)	90×89	90×90	80×90	60×65
	菌落色澤	白　色	白　色	白　色	灰白色但氣生菌絲稀疏
529	菌落直徑 (mm)	88×88	85×85	80×85	65×70
	菌落色澤	灰綠色	橄欖色	灰綠色	橄欖色
886	菌落直徑 (mm)	75×75	79×79	70×70	60×65
	菌落色澤	墨綠色菌絲由中央起成放射形生長氣生菌絲茂盛高2mm	同　左	灰綠色	墨綠色氣生菌絲生長稀疏
1124	菌落直徑 (mm)	85×85	70×80	80×80	60×60
	菌落色澤	灰綠色外圍爲5mm寬之白色菌絲	同　左	同　左	較左爲深色菌絲亦較粗
288	菌落直徑 (mm)	80×85	85×89	75×80	65×78
	菌落色澤	棕灰色氣生菌絲密生呈絨毛狀	同　左	淺棕色氣生菌絲不如糙米培養基良好	棕灰色氣生菌絲生長比糙米培養基較稀而粗
K 67	菌落直徑 (mm)	80×85	85×85	80×85	62×70
	菌落色澤	墨綠色	同　左	同左氣生菌絲生長較差	同左菌絲較粗
111	菌落直徑 (mm)	75×75	75×75	72×75	63×65
	菌落色澤	墨綠色邊緣不完整外圍爲一圈白色菌絲寬10mm	同　左	色澤稍淡外圍白色菌絲寬10～20 mm	墨綠色氣生菌絲較粗

草 7	菌落直徑（mm）	60×60	68×68	60×60	50×50
	菌落色澤	墨綠色年輪狀菌絲生長密外圍白色菌絲寬10～15mm	同　左	同左但外圍白色菌絲寬20mm	同左但外圍白色菌絲寬10～15mm

4. 稻熱病病原菌對水稻鑑別品種之感病反應：

本年度接種供試菌有 529 等七菌號，菌號529, 1124, 1127, 自臺中光復 1 號所分離，菌號1155自臺中嘉農 242 分離，菌號 886 自嘉義臺中糸比33號分離，草 2 則自臺北本所附近農田雜草 Oryzae satiua Lin 所分離者。接種期間溫度爲 25°C 左右，每處理三重覆，前後舉行三次接種，所得結果如表四。

表四　幾種稻熱病病原菌號對判別稻種之感病反應

代號	品　種　名	529	886	891	1124	1127	1155	草 2
1	臺 中 65 號	M 1	S 5	M 1	I	S 1	I	I
2	高 脚 柳 州	I	M 3	M 1	I	M 1	I	I
3	崑山五香粳	R 1	S 6	S 3	M 4	S 2	M 1	I
4	高雄大粒清油	I	I	I	I	I	I	I
5	稗 稈 稻	I	M 1	I	I	I	I	I
6	關 東 51 號	I	I	I	I	I	I	I
7	嘉農育280號	I	S 1	I	I	I	I	I
8	臺 中 171 號	I	S 1	I	I	I	I	I
9	臺中糸比33號	I	S 3	I	I	I	I	I
10	光 復 1 號	I	S 4	I	I	I	I	I
11	嘉 農 242 號	I	S 1	I	I	I	I	I
12	Cutsugulcle	R 1	S 4	I	I	S 2	I	I
13	臺中低脚烏尖	I	M 1	I	I	SR 2	I	I
14	農 林 21 號	I	I	I	I	S 1	I	I
15	Sensho	I	I	I	I	I	I	I
16	Natala	M 1	M 3	I	I	M 1	I	I

根據接種試驗結果，16鑑別品種對菌號間之反應殊有差異，此是否即生理小種之存在，尙待商確。玆按各菌數致病力强弱暫分爲下列五類，而暫未冠以生理型號。

A類：對臺中65號，崑山五香粳，嘉農育 280 號，臺中 171 號，臺中糸比33號，光復 1 號，嘉農 242 號，Cutsugulcle 等 8 種顯示感染性病斑，高雄大粒清油，農林21號，Sensho 等三品種顯示無感染，即16判別品種中 8 品種呈感病性病斑，4 品種呈中間性病斑型，3 品種呈無感染，因此可以說屬此型菌號之感病能力在供試菌號中最强。……………………………………………886 菌號

B類：對臺中65號，崑山五香粳，Cutsugulcle，農林21號等四品種呈感病性病斑型，臺中低脚烏尖在感病性病斑中混有少數抗病性病斑，此類中特別與A類不同者，即農林21號在A類無感染，於本類中呈感病性病斑型 Natala及高脚柳州與A類相同呈中間性，其餘稻種均無感染。…1127菌號

C類：此類僅感染崑山五香粳一種，又病斑型呈中間性，其他判別稻種皆無感病，可以說供試菌號中感病能力最弱者。……………………………………………………………1124；1155菌號

D類：對崑山五香粳呈感病性，臺中65號及高脚柳州呈中間性，其餘品種均無感染。…891菌號

E類：與D類有顯著之差異者爲崑山五香粳，在D類呈感染性，但本類中呈抗病性，又 Cuts-

ugulcle 亦呈抗病性，Natala 呈中間性，其餘均無感染。……………………………………529 菌號

四、討　　論

欲抑制稻熱病之蔓延，稻作品種必須具有優良之抗病性。但以往在不同地區，不同品種間抗病性之强弱常有差異，此究由於環境因子，稻品種之生理反應，抑或由於病原菌生理小種之存在，因在本省尙未有系統之研究，誠難論斷也。故爲育成良好之抗病品種及其栽培地區之選擇，應先探究病原菌生理分化情形，如能明瞭本省稻熱病菌生理小種之存在，種類與分佈，則對稻熱病防治上之收效將事半功倍矣。

溫度對病原菌之發育具有決定性之影響，溫度不適則病原菌卽無法成長爲害。以往有很多報告，大致認爲28°C前後最適於病原菌之發育。末松氏(1916)指出稻熱病菌發育適溫爲 26°～30°C°，西門氏 (1926, 1927) 認爲生長可能溫度 (8～9)～(36～37)°C，發育最適溫爲26°～28°C，澤田氏(1926)報告本菌之發育可能溫度爲10°～37°C，發育最適溫爲 26°～28°C，又末田氏 (1928) 安部氏(1930)吉井氏(1936)等之研究結果與前述者符合。不同系統之病原菌其生長適溫亦有差異，杤內氏(1932)將稻熱病菌按生長適溫分爲二羣，卽25°C生長最良者與28°C生長最良者。小西氏(1933)以24種培養系統供試驗觀察結果，按溫度對病原菌之發育之影響分爲三羣，其中有些系統至32°C尙可生長良好，少數系統於36°C仍可繼續生長。杤內氏，島村氏(1932)應用稻藁煎汁培養基，觀察稻熱病之生長狀況結果，有些系統在25°C之生長比28°C差，有些系統則反之，25°C優於28°C，本試驗供試七種菌號均於 28°C下生長最好，菌號間之生長情形有差異，菌號 891 在 19, 25°, 34°C 下之生長速度較其他菌號爲佳，草 7 則在各溫度下之生長均較其他菌號爲差。

關於稻熱病菌在不同 pH 值下之生長，本試驗自 pH 4.5～8.5 病原菌絲均能發育，pH 值低時病原菌絲生長細密，自 pH 6.5 以上各菌號之菌絲生長漸趨稀粗。菌號 891, 529, K67, 111, 草 7，均在 pH 4.5 時生長最佳。逸見氏(1949)曾報告稻熱病菌絲之發育自 pH 4.8～9.7 之範圍內均可生長，而以 pH 5.5 至 8.7 之間之生長較良，pH 4.4 以下，9.7以上之生長極差，至 pH 4.0 及 10.7 時均不能發育。西門氏 (1926) 測定稻葉汁之 pH 值爲 6.0 左右，但人工培養基上其生長範圍則更廣，自 pH 4.3～9.87 均可生長。

病原菌在不同營養培養基上之生長情形，供試菌號除1124菌號外，均於高粱煎汁培養基上之生長最爲優良，其次爲糙米煎汁培養基，玉米培養基再次之，合成培養基 (Czapek 氏培養基) 上之生長最差。各菌號所表現之不同菌落色澤，氣生菌絲生長情形，生長速度等在不同培養基上均很固定。杤內氏(1932)按稻熱病原菌在培養基上之性質區分爲九種生態系，小西氏(1933)利用馬鈴薯煎汁培養基培養稻熱病菌，按其表現之菌落色澤及形態加以歸類。本試驗利用糙米培養基及參照其他培養基上培養結果，按菌落之形態色澤之不同而分爲幾種生態型。

關於稻熱病菌生理型之分類，逸見氏 (1949) 根據稻熱病菌供試菌絲接種於寄主後觀察其病原性之强弱類別爲11羣。1959年日本農林省振興局植物防疫課報告北海道農試場，四菌羣23菌型；長野農試所分爲 3 race 羣，25 races；愛知農試所接種結果分爲18 races，大分農試所分爲5 race 農技研據接種後按病斑型可類別爲 3 race 羣，14 races。鈴木氏 (1953) 按稻熱病菌分生孢子之發芽型，附着器形成型，附着器之形態及在稻體上形成附着器能力等四性質之略呈固定性質，將日本產稻熱病菌類別爲12 Homotype 系統，氏並指出稻熱病菌有 Heterocaryotic 現象之存在，使本項研究趨於複雜化。

本試驗結果，不同菌號之致病力有顯著的差別，16鑑別品種對供試接種菌號之感病反應亦有明顯之差別，自雜草上分離所得之 Piricularia sp 對各水稻品種均無感病反應，但據逸見(1949)報告自雜草 (Panicum Songrinale C.) 上所得之 Piricularia sp 對稻苗葉具有侵害的能力，又鈴

木氏(1953)指出 P. oryzae 菌應用浸漬接種法接種結果，有的菌系統除可浸入稻之外，其他雜草亦呈有侵入之反應。

本年度按各菌號致病力之强弱暫分爲五類，至於究有幾種生理型之存在，此問題目前正繼續在研討中。

五、摘　　　要

本試驗欲探求本省稻作稻熱病病原是否有生理型存在，種類若干及分佈情形，而擧行，玆摘出本年度所得結果如下：

1. 供試七種菌號均於28°C下生長最優良，其中 891 菌號在 19, 25 及34°C下均較其他菌號之生長爲佳，各菌號雖均於28°C下生長優良，但在各種溫度下之生長速度有異。
2. 供試七種菌號於 pH 4.5～8.5 之間，菌絲均能發育，但 pH 值較低時菌絲生長較細密，較高時菌絲生長趨稀而且粗。又有些菌號於 pH 6.5 時，有些於 pH 5.5 時生長爲良。
3. 應用植物煎汁培養基培養病原時均比合成培養基之生育爲佳，其中高粱煎汁培養基最優良。
4. 供試七種菌號，應用噴霧接種法，觀察對16判別品種之感病反應頗有差異，本年度按各菌號致病力之强弱暫分爲五類，以明瞭其概況。

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STUDY ON THE PHYSIOLOGICAL RACES OF *Piricularia oryzae* Cav.

by

C. H. HUNG, C. C. CHIEN & S. Y. LIN

SUMMARY

In order to explore the existence of the physiological races of Piricularia oryzae, the rice blast fungus, together with their distribution and kinds, this experiment was carried out.

1. The relation of temperature to the growth of P. oryzae was studied by measuring the colonies' diameter developed on rice-polished agar. The optimum temperature for the growth of the eight isolates having been tested was 28°C. Under same temperature the isolates showed different growing rate. The growth of isolate 891 was better than others at 19°, 25°, and 34°C, but inferior to isolate 886 at 28°C. Isolate G. 7 showed the slowest growth of all isolates.

2. In this studies, the isolates of P. oryzae were cultured at pH 4.5, 5.5, 6.5, 7.5, and 8.5, five grades. Under lower pH. value, the aerial hyphae was well developed, rather minute, and it grew coarser according as the pH value became higher. The optimum pH value of the isolates tested were varied, some at pH 6.5, while others at pH 5.5, or pH 4.5.

3. The growth rate of isolates on four kinds of media displayed the better growth on vegetable decoction media, specifically on Soghum medium, than those on the synthetic medium.

4. Inoculation test held by spraying respectively seven isolates' spore suspention on 16 standard varieties of the rice has shown apprently the different infection types. According to the reaction of rice seedlings, the pathogenicity of the isolates so far tested were primarily classified into five types.

STUDIES ON THE PHYSIOLOGIC RACES OF *PIRICULARIA ORYZAE* CAV. (II)

by

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The rice blast caused by *Piricularia oryzae* Cav. is one of the most important rice diseases in Taiwan. Hashioka (1950) studying the "mechanism of prevalence" of the disease in the tropics, recognized two major epidemiological types: the temperate-subtemperate and the subtropical-tropical. An epidemic occurrence of the temperate-subtemperate type is determined chiefly by factors related to the growth of the parasite, whereas that of the subtropical-tropical type, chiefly by those related to the resistance of the host. Accordingly, for controlling blast disease in the subtropical and tropical regions emphasis should be laid on the increase of host resistance.

Pathogenic and cultural specialization in rice blast fungus has been studied by several workers. Sasakii (1922-1923) reported three strains of the blast fungus, one being highly virulent and the others less so. Nozu (1928) identified a fourth strain of the fungus. Tochinai and Shimamura (1932) compared 41 cultures of *P. oryzae* and classified them into 9 distinct cultural types. Konishi (1935) studied possible correlation between cultural type and pathogenicity of the fungus, but drew no conclusion. Aoki (1935) described 14 types of *P. oryzae* according to their cultural characteristics. Abe (1936) found marked differences in virulence among strains of the fungus. Inoue (1930) classified isolates into strains on the basis of their ability to decompose cellulose. Comparing the virulence of the fungus by inoculation to leaf and ear of rice, Hemmi (1940) defined 11 strains. Since 1952, Suzuki (1953) has analyzed a large number of single-spore isolates of the blast fungus in an attempt to differentiate them, and established 12 homokaryotic types with respect to ways of spore germination, the ability to form appressoria at different temperatures, etc.. Goto et al. (1960) recently identified races of *P. oryzae* in Japan on the basis of their pathogenicity to selected rice varieties. In America, Latterel et al. (1954) reported the existence of at least two races of *P. oryzae*. In further studies, these authors found fifteen physiologic races characterized by disease reactions in ten rice varieties (Latterell et al., 1960). In 1962, Atkins reported the prevalence and distribution of fifteen pathogenic races of *P. oryzae* in the United States.

Field evidence indicating possible existence of physiologic races in Taiwan

* The authors wish to acknowledge their indebtedness to Dr. R. J. Chiu of Chinese-American Joint Commision on Rural Reconstruction for his valuable suggestions and criticisms both during the course of this investigation and preparation of this paper.

was first obtained by Li (1957) who observed difference in varietal reaction in blast nurseries established at four locations in 1956. This observation stimulated much research activities on this problem. The study on physiologic races of the blast fungus started in Taiwan Agricultural Research Institute in 1957, and in Academia Sinica, 1960. Hung et al. (1961) employing 16 differential rice varieties recognized five pathologic types among the seven isolates tested. The same group of differential varieties was used in the present studies with 67 isolates collected in 1960, 141 isolates in 1961 and 146 in 1962. Results to be presented here provide a further proof of the existence of physiologic races of *P. oryzae* in this island. The distribution and relative prevalence of the races are also described.

Materials and Methods

Cultures: A total of 354 isolates of *P. oryzae* was obtained from 95 varieties or selections of rice grown in the uniform blast nurseries established in five localities, namely, Ilan, Tungshu, Chiayi, Pingtung and Taitung. The usual tissue plating method was used for obtaining the pure cultures. All cultures were maintained on 2 per cent rice-polish agar slant. Before testing for pathogenicity, the original isolates were subjected to single-spore isolation using the Lambert's cylinder loop needle (Lambert, 1939). A dilute spore suspension was dispersed over the surface of 2 per cent agar plate. After incubating at 28°C for at least 5 hours, the germinating single-spores were cut out and transplanted individually to yeast-starch medium in a vessel (Misato et al., 1961). Spores were usually produced in sufficient numbers in 14 to 18 days for use in plant inoculation.

Differential Varieties: Sixteen varieties of rice used as differentials (Table 1) were selected by the late H. C. Li (1957). These are represented by 11 varieties of *Japonica* type and five varieties of *Indica* type. Of the *Japonica* type, one is from mainland of China, three from Japan and seven locally bred varieties. Of the *Indica* type, two are the upland rice and three the lowland rice.

Table 1. Sixteen rice varieties employed as differentials for identification of physiologic races of *Piricularia oryzae*.

Variety	Type	Origin
Kung-shan-wu-shen-ken	Japonica, lowland	Mainland, China
Taichung 65	Japonica, lowland	Taiwan
Pai-kan-tao	Japonica, lowland	Taiwan
Taichung 171	Japonica, lowland	Taiwan
Chianung 242	Japonica, lowland	Taiwan
Kwang-fu 1	Japonica, lowland	Taiwan
Chianung-yu 280	Japonica, lowland	Taiwan
Taichung line 33	Japonica, lowland	Taiwan

Kanto 51	Japonica, lowland	Japan
Norin 21	Japonica, lowland	Japan
Sensho	Japonica, lowland	Japan
Cutsugulcul	Indica, upland	Taiwan
Natala	Indica, upland	Taiwan
Kao-chio-liu-chou	Indica, lowland	Taiwan
Kaohsiung-ta-li-chen-yu	Indica, lowland	Taiwan
Taichung-ti-chio-wu-chien	Indica, lowland	Taiwan

Growth and inoculation of test plants: Inoculations were made in the green house on 16 differential rice varieties growing separately in an iron flat (30 cm × 30 cm × 7.5 cm). Prior to inoculation, 2% ammonium sulfate solution was top-dressed to the flats twice, at the rate of 25 ml per flat for each application. Two weeks after planting (3–5 leaf stage) the seedlings were inoculated by spraying over leaves with spore suspension which contained 10 to 20 millions of fresh conidia in 100 ml distilled water. Check flats were sprayed with distilled water. Each flat was then kept under plastic sheet on a wooden frame for 20 hours (Anderson 1947). Reading of the disease reactions was made 4 to 9 days after inoculation, depending on the environmental conditions.

Grouping of Infection Types: According to Abumiya (1959), four major infection types of blast disease on rice plants can be recognized on the basis of lesion development and its final appearance.

R type (Resistant): (w)-(p)-b-yb.

M type (Moderately resistant): (w)-(p)-(pg)-bg.

S type (Susceptible): w-p-pg-ybg.

O type: Absence of lesion response.

The symbol ( ) indicates short duration of the described reaction. These systems for grouping infection types were adopted in the present studies except

Table 2. Systems for grouping blast infection types in the present experiment as compared to those adopted elsewhere.

Publisher	Year	Designation							
Hashioka	1950	E	D	C	B		A		
Takahashi	1951	0	1	2	3	5, 6	4		
Abumiya	1953	0	b	yb	bg	ybg	pg	p	w
Abumiya	1959	O	R		M	S			
Goto et al.	1960	HR	R		RS	HS	S		
Latterel et al.	1960	0	1	2	3	4	5		
The present Authors		R			M	S			

that the absence of lesion response was also recorded as R reaction. Somewhat different scales of infection types were proposed by Hashioka (1950), Latterel et al. (1960), Takahashi (1951), and Goto et al. (1960). A comparison of our system with those proposed by others for grouping infection types is given in Table 2.

Experimental Results

Sporulation: Conidia were needed in quantity for use as inocula in pathogenicity tests. It is therefore very important to study the sporulation of the fungus. The sporulability was found to differ with isolates and culture media used. With most isolates, about 60-80×10^5 spores per culture tube were produced on yeast starch agar slant (Yeast extract, 2 g; soluble starch, 10 g; agar, 16 g; water 1,000 ml). Some isolates, however, failed to produce large number of spores on the same medium. Of about 200 isolates tested, 50 yielded more than 5×10^5 spores per tube, 20 formed fewer than 10×10^4, and the rest produced about 9×10^5 spores per tube. Several natural media, e.g., broad-been agar, kindney-bean agar, string-

Table 3. Sporulation of five isolates of *P. oryzae* on different media (pH 5) after two weeks of incubation at 28°C.

Isolate	Medium					
	Yeast-starch agar		Rice-polish agar		Rcie-straw agar	
	Amount*	r**	Amount	r	Amount	r
1Ta-5R	3.00	1.65	2.80	1.63	2.90	1.65
1C-14R	1.40	1.14	0.50	0.70	0.50	0.70
0S-45S	173.40	12.78	28.90	5.33	1.30	3.53
1I-31N	28.60	5.28	2.40	1.47	2.90	1.62
1Ta-5S	134.60	11.19	14.10	3.59	17.30	4.03
L. S. D. 5%		1.701		0.424		0.456
L. S. D. 1%		2.282		0.569		0.612

Isolate	Medium				L. S. D. 5%	L. S. D. 1%
	Rice-seedling agar		String-bean agar			
	Amount	r	Amount	r		
1Ta-5R	1.00	1.00	3.50	1.78	0.233	0.310
1C-14R	0.50	0.70	0.50	0.70	0.339	0.454
0S-45S	6.30	2.42	14.40	3.67	0.745	0.999
1I-31N	16.10	3.97	17.40	4.04	0.570	0.765
1Ta-5S	4.30	1.95	10.60	3.17	1.218	1.634
L. S. D. 5%		0.391		0.582		
L. S. D. 1%		0.525		0.781		

* Average number of spores per 1/30,000 ml.

** Square root of the average number of spores.

bean agar, onion agar, Tochinai-Nakano agar, rice-polish agar, rice-straw agar, etc., also allowed abundant conidial production. With some isolates, these proved to be better media than the yeast starch agar. On corn-meal agar and Czapek's agar very few spores were formed. Table 3 showed the sporulability of several isolates on five different media. Isolates also varied in the length of cultivation that effected spore formation. Most isolates produced considerable amount of spores after one week of incubation at 25–31°C, but a few failed to do so. This is particularly true when yeast starch medium was used. Isolate 0C-5N, for example, produced very few spores after 14 days of cultivation on yeast-starch agar slant at 27–28°C but yielded abundantly after 3 weeks. This phenomenon was not observed with rice-polish agar, however. According to Anderson and Henry (1948), the time required for maximum sporulation may differ with isolates, and with the way in which the cultures are handled. In our results the maximum sporulation was usually obtained after 14 days on yeast-starch agar slant at 27°C by mass mycelial transfer; 4–7 days in vessel containing 40 ml of yeast-starch agar seeded with spore suspension; or 9–12 days in the aerated flask containing autoclaved rice grains. Amount of spores in inoculum was found to be an important factor affecting sporulation, the incubation period required for the maximum production of spores was shortened by using heavier inoculum.

Identification of Races: The 354 isolates tested during 1960-1962 were identified as to belong to 19 physiologic races. Varietal reactions to these races are shown in Table 4. These races can be conveniently distinguished into seven race groups as follows:

Group A: Isolates of this group containing one single race (Race 1) were either avirulent or weakly pathogenic to the 16 differential varieties. No lesions or only resistant lesions were produced under the experimental conditions. Apparently, some isolates of this group might have lost their pathogenicity upon culturing, as evidenced from the fact that they originated from one of the differential varieties and were obtained from susceptible leaf lesions.

Group K: Isolates that constituted this monoracial (Race 2) group caused susceptible leaf lesions only on the variety Kung-shan-wu-shen-ken. No infection or resistant leaf lesions were induced on other varieties. This race group also contained isolates that were obtained from susceptible lesions on differential varieties other than Kung-shan-wu-shen-ken, a fact suggesting the loss of pathogenicity during cultivating.

Group N: This group was represented only by a few isolates of race 3 causing susceptible lesions on the *indica* variety Natala but resistant lesions on other differential varieties. One isolate of this group originally from a susceptible lesion on Taichung 65 failed to induce susceptible reaction on this same variety upon testing.

Table 4. Physiologic races of *P. oryzae* identified in Taiwan during 1960-1962.

Differential variety	Race designation										
	A	K	N	J				I			
	1	2	3	4	5	6	7	8	9	10	11
KSWSK	R	S	R	S	S	S	S	R	R	R	R
TC 65	R	R	R	R	S(m)*	S	R	R	R	R	R
PKT	R	R	R	R	M(r)	S	R	R	R(s)	R	S
TC 171	R	R	R	R	R	R	R	R	R	R	R
CN 242 } KF 1 }	R	R	R	R	R	S	R	S	R	R	R
CNY 280 } TCL 33 }	R	R	R	R	R	R	R	R	R	R	R
KT 51	R	R	R	S	M	S	S	R	R	R	R
NR 21	R	R	R	S	M	S	S	S	R	R	R
SS	R	R	R	S	M	S	S	S	R	S	S
Cuts.	R	R	R	S(m)	S	S	S	R	R	R	S
Nat.	R	R	S	S	S	S	S	S(m)	S	S	R
KSLC	R	R	R	R	S(m)	S	S(m)	S	S(r)	S	S
KH-TLCY	R	R	R	R	M	S	S(m)	S	S	S	S
TC-TCWC	R	R	R	S(m)	R	S(m)	S(m)	S	S	S	S

Differential variety	Race designation							
	P					X		
	12	13	14	15	16	17	18	19
KSWSK	S	S	S	S	S	S	S	S
TC 65	S	S	S	S	S	S	S	S
PKT	S	S	S(m)	S(r)	S	R	S	R
TC 171	S	S	S	S	S	R	R	S
CN 242 } KF 1 }	S	S	S	S	S	R	R	S
CNY 280 } TCL 33 }	S	S	S	S	S	R	R	R
KT 51	S	R	S(r)	R	S	R	R	S
NR 21	S	R	S	R	S	R	R	R
SS	S	R	S(m)	M	S	R	R	R
Cuts.	S(m)	S	S(r)	R	S	R	R	R
Nat.	S(m)	S(m)	S	S	S	R	S(m)	S(m)
KSLC	S	S	S	R	R	R	R	R
KH-TLCY	S	S	S(r)	R	R	R	R	R
TC-TCWC	S	S	M	R	R	R	S	R

* The small letters in parentheses denote the minor infection types observed in the inoculated plants.

Group J: Isolates of four races (4, 5, 6 and 7) that constituted this group produced susceptible leaf lesions on Kung-shan-wu-shen-ken as well as on the two upland *indica* varieties. Lesions of susceptible or intermediate types were induced on the three *japonica* varieties. The four races, however, differed in their reactions on other differential varieties.

Group I: This race group was also composed of four races (8, 9, 10 and 11) which produced susceptible leaf lesions on the three local varieties of lowland *indica* rice, but, resistant reaction on Kung-shan-wu-shen-ken. All or most of the locally developed *japonica* rice varieties responded with resistant reaction.

Group P: Five races (12, 13, 14, 15 and 16) were taken under this group for the susceptible type lesions on Kung-shan-wu-shen-ken and on the seven locally developed *japonica* varieties. The variety Natala from which Taichung line 33 derived its blast resistance also gave susceptible response to these five races. Race 12 of this group was the most virulent one among the 19 races so far recognized. It produced susceptible leaf lesions on all 16 differential varieties.

Group X: This was apparently a highly heterogeneous race group composing of three races (17, 18 and 19) which had few pathogenic properties in common. Susceptible reaction was produced by isolates of the three races on Kung-shan-wu-shen-ken and Taichung 65.

Different races were observed among cultures derived originally from one single-spore isolate. It is not known whether this was due to mutation or intermingling of genetically different nuclei in vegetative hyphae within a heterokaryotic system of the fungus (Suzuki 1962).

Prevalence and Geographical Distribution of Races: The geographical distribution pattern of 19 races of *P. oryzae* identified in Taiwan during 1960–1962 is shown in Table 5.

Races 1, 2, 7, 10, 12, 13, 14, 17 and 18 were obtained from all five areas where blast nurseries were located and collections of the fungus made. Of these races, 13 and 17 seemed to be the most predominant, being isolated over 40 times within the three year period. Races 3, 8, 11 and 19 were found in fewer than four times and confined to two or three localities. Of the 7 race groups, group P could be considered as the most prevalent and widely spread. Races of this group were isolated 121 times and found in all five localities.

The 19 races identfied did not all appear each year during the three year period. The actual number of races detected was 13 in 1960; 12 in 1961; and 17 in 1962. In consideration of locality, 13 races were found in Taitung area; 17 in Pingtung; 15 in Ilan; 14 in Tungshu; 13 in Chiayi. The distribution of the major races in the five areas was as follows: Ilan, races 13 and 17; Tungshu, races 9, 10, 12 and 13; Chiayi, races 12 and 13; Pingtung, races 10, 13, 14, and 17; Taitung, races 12 and 17.

Table 5. Geographical distribution of physiologic races of *P. oryzae* isolated in Taiwan during 1960–1962.

Source	Year	Number of isolates										
		Group A	K	N	J				I			
		Race 1	2	3	4	5	6	7	8	9	10	11
Ilan	1960	1	1									
	1961	2	1		4						1	
	1962	10	2	1			2	2		2		1
Tungshu	1960	3	1		2				2	3	2	
	1961	1	1		2					9	5	
	1962				1		1	1		2	1	
Chiayi	1960										2	
	1961	3	1									
	1962	4	6		2	1		1			1	
Pingtung	1960			1								
	1961	3	1							2	5	
	1962	6	6	1		3	1	2			4	2
Taitung	1960								2			
	1961	1	5							2	2	
	1962	3	2	1	3	2	1	1				
Number of isolates	1960	4	2	1	2	0	0	0	4	3	4	0
	1961	10	9	0	6	0	0	0	0	13	13	0
	1962	23	16	3	6	6	5	7	0	4	6	3
Total		37	27	4	14	6	5	7	4	20	23	3

Source	Year	Number of isolates										Number of races	
		Group P					X			Total			
		Race 12	13	14	15	16	17	18	19				
Ilan	1960	1	1	2			1		1	8	57	7	15
	1961		2	12			1	1		24		8	
	1962		1				1	3		25		10	
Tungshu	1960	4	11		1		1			30	80	10	14
	1961	3	6	5			1	7		40		10	
	1962	1	1					2		10		8	
Chiayi	1960	2	3	1	1					9	68	5	13
	1961	2	8	3			3	1		21		7	
	1962	2	6		1	6	3	5		38		12	
Pingtung	1960	2			3					6	71	3	17
	1961	1	4	1	4		3		2	26		10	
	1962		1	2		1	8	2		39		13	
Taitung	1960	2			1		8		1	14	78	5	18
	1961	1	6	2			9	2		30		9	
	1962	4		2	4	4	5	2		34		13	
Number of isolates	1960	11	15	3	6	0	10	0	2	67		13	
	1961	7	26	23	4	0	17	11	2	141		12	
	1962	7	9	4	5	11	17	13	0	146		17	
Total		25	50	30	15	11	44	24	4	354		19	

Cultural Characteristics: On yeast-starch medium, six distinct cultural types were discerned among the isolates tested.

Type A: White colony with aerial mycelial growth 1 mm in height, and sparse conidial formation.

Type B: Colony greyish white with aerial mycelial growth 1 mm in height, and sparse conidial formation.

Type C: Colony greyish in color with dark concentric rings, aerial mycelium 2 mm high. Later white tufty oppressed mycelium appearing on the surface. Spores abundant.

Type D: Colony greyish in color with aerial mycelial growth 2 mm in height, and rather profuse sporulation.

Type E: Colony with white coarse aerial mycelial growth 3-4 mm in height and profuse sporulation.

Type F: Colony slightly brownish with mycelial growth 1 mm in height, Sporulation varied from sparse to abundant.

Cultural types of blast fungus were to some extent associated with pathogenicity. However, there was no definite correlation between cultural characters and pathogenic races. Sometimes isolates of different cultural types were pathogenically alike; and sometimes isolates of same cultural type produced different plant reactions in the differentials. Cultures of *Piricularia* sp. isolated from *Panicum repen* (Grass) showed different cultural characteristics from *P. oryzae.* Slower growth was the most conspicious one. Isolates of cultural types C, D and E usually had a strong pathogenicity, while types A and B were weakly pathogenic. Isolates of type F varied from being weak to strong.

Cross-infectivity Tests with P. oryzae and P. sp.: Isolates of *Piricularia oryzae* from rice and *P. sp.* from *Panicum repen* were used to inoculate each other's host. No infection was obtained either on rice by isolates from *P. repen* or on *P. repen* by isolates from rice.

Summary

A total of 354 cultures of *P. oryzae* isolated from 95 varieties or selections of rice grown in five localities of Taiwan were grouped into 6 distinct cultural types according to their cultural characteristics on yeast-starch agar. Using 16 rice varieties as differentials, these isolates were identified as to compose 19 physiologic races which could further be conveniently distinguished into seven race groups on the basis of their ability to attack the differentials. The distribution of the major races in the five areas is as follows: Ilan, Races 13 and 17; Tunshu, Races 9, 10, 12 and 13; Chiayi, races 12 and 13; Pingtung, races 10, 13, 14 and 17; Taitung, races 12 and 17. Of the 7 groups, group P could be considered as the most prevalent and widely spread.

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稻熱病病原菌生理型之研究 (II)

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摘　　要

1. 從1959年起，自全省稻熱病測定試驗病圃（宜蘭、東勢、嘉義、屏東、臺東等地）及臺北、桃園、新竹、臺中、臺南、高雄等地區採集稻熱病病害標本。經人工純系單胞分離後，在酵母培養基上鑒別其培養型，並於溫室內舉行人工接種在十六鑒別稻品種上，以測定各菌株之感病反應。

2. 純系分離之稻熱病病原菌，在酵母培養基上，可分為6種培養型，以 A, B, C, D, E 及 F 等表之。C, D, E 三型常具強之病原性；A, B 兩型之病原性較弱；F 型之病原性不定。

3. 354個純系分離之稻熱病病原菌，接種於鑒別稻種上，得到19種不同之生理小種，以 1, 2, 3～19 等表示之。並以品種間感病反應之差異，可組成為7個小種羣。

4. 19生理小種中，1960年發現13小種；1961年12小種；1962年17小種。宜蘭臺北區共15種生理小種，以13及17最多；臺中東勢區共14種生理小種，以9, 10及13最多；嘉義地區共13種生理小種，以12及13最多；屏東地區共17種生理小種，以10, 13, 14及17最多；臺東地區共18種生理小種，以12及17最多。

Physiologic Races of *Piricularia oryzae* in Taiwan

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As early as 1922, Sasaki showed that isolates of the rice blast fungus, *Piricularia oryzae* Cavara, differ in their pathogenicity. To certain host varieties, some isolates are more virulent than others (Sasaki, 1922a, 1923). Systematic attempts to differentiate physiologic races of the fungus on the basis of infection types in a given number of rice varieties had not been made, however, until recent years. The joint work on the race problem in Japan, described briefly in chap. 13, is especially notable (Goto *et al.*, 1961).

Grouping of blast isolates into physiologic races by using ten differential varieties (see chap. 14) also has been reported from the U.S. (Latterell, Tullis, and Collier, 1960). In Taiwan, studies on physiologic races of the blast fungus are being carried out independently at the Taiwan Agricultural Research Institute (TARI) and the Academia Sinica. Non-identical sets of differential varieties are used for race identification.

This chapter covers the work at both institutions. Some aspects of race study and preliminary results obtained at TARI prior to 1959 have been reported elsewhere (Chang, 1961b; Hung and Chien, 1961; Hung, Chien, and Lin, 1961). Unpublished data obtained during 1960–1962 are included here. Information about the race work at the Academia Sinica is based mainly on a recent paper by Kou *et al.* (1963).

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FIELD EVIDENCE SUGGESTING THE EXISTENCE OF RACES OF THE BLAST FUNGUS

Two kinds of field evidence generally are taken to indicate the existence of physiologic races of a pathogen: (*1*) the gradual breakdown of disease resistance in a variety in given locations, and (*2*) a great difference in varietal reaction according to varied locations. An unequivocal case of the first kind has not been recorded with blast disease in Taiwan. Various rice workers have observed several cases of the second kind. Hashioka (1952a, 1952b) tested eight varieties for blast infection in seven locations during 1934–1936 and found a greater difference in varietal reaction due to locations than to yearly fluctuation. He made a similar observation during 1937 and 1938 in another series of nursery tests with eight varieties. Since Hashioka measured susceptibility on such quantitative bases as percentage of infected leaves and number of lesions per leaf (now believed to be less reliable reflections of varietal susceptibility or resistance), the observed difference with locations hardly can be taken to indicate that different race patterns were involved. Another fact defying a successful detection of race patterns is that all the varieties Hashioka used could be rated as susceptible by today's standards.

Another recent observation that suggests the possible existence of races of the blast fungus was obtained by Li (1957) from blast nurseries established in four locations in 1956. Of the 20 varieties tested, five—Taichung 171, Taichung line 33, Kwang-fu 1, Chianung 242, and Custugulcul—had heavy blast infection producing susceptible lesions at Tungshih but gave a resistant reaction at Ilan, Chiayi, and Pingtung. Other varieties showed rather minor differences in disease reaction with locations. Such observations raised the question of physiologic races of the blast fungus for the first time in Taiwan, and, as a result, a study of the problem was started at TARI in 1957.

A blast nursery testing program first initiated in 1956 has been continued with the number of varieties varying from year to year. The results revealed that five resistant varieties and lines—Taichung Nos. 181, 182 and 183, Taichung lines 47220 and 48212—were found susceptible at Pingtung but resistant in four other locations during the first crop of 1961. This observation, however, was not obtained in 1962. Another striking difference in blast reaction with locations also was found in varieties Pai-kan-tao and C 113, which gave consistently heavier blast infection for two years in Kwangshan in eastern Taiwan than in four other locations in the western part. As shown in Table 15–1, the main infection types also differed by location. The existence of physiologic races of the blast fungus seems to be the most likely explanation for these observations.

SOME METHODOLOGICAL ASPECTS OF RACE STUDIES

ORIGIN OF TEST ISOLATES

The majority of blast fungus collections for race identification at TARI were obtained from the blast nurseries established, as we have said, in five locations (Ilan, Tungshih, Chiayi, Pingtung, and Kwangshan), where identical sets of rice lines or varieties were tested. Pure cultures were obtained from the diseased materials by the usual tissue-plating method. Spores thus produced were subjected to single spore isolation. Usually one such isolate was made from each host variety at the same location. Only in rare cases were two or three isolates obtained from one single collection. Re-

TABLE 15–1: Rice Variety Reactions to Blast Disease in Various Locations as Observed in 1961–62

Year of testing and variety tested	Blast reaction [a] and location				
	Ilan	Tungshih	Chiayi	Pingtung	Kwangshan
1961					
Taichung 181	R	R(m)	I	S(m)	R(m)
Taichung 182	R	M	R	M(s)	R
Taichung 183	R	R	R	M(s)	R
Taichung line 47220	R	R	R	S(m)	R(m)
Taichung line 48212	R	R	I	S	R
C 113	R	M(r)	R(m)	R	S(m)
Pai-kan-tao	R	M(r)	R(m)	R	S(m)
1962					
Taichung 181	R(m)	R(ms)	R	M	R(s)
Taichung 182	R	R	R	R	R
Taichung 183	I	M(r)	S(r)	R(m)	R(s)
Taichung line 47220	I	S(mr)	R	R	R(s)
Taichung line 48212	R	R	R(s)	R	R(s)
C 113	I	M(rs)	R	M	S
Pai-kan-tao	R(m)	R	R	R	S(r)

[a] The major infection types observed in rice varieties are represented by letters *I*, *R*, *M*, and *S*, denoting immune, resistant, intermediate, and susceptible. The small letters in parentheses denote the minor infection types observed.

fraining from use of duplicate isolates from the same collection permits a more representative race pattern for the locations.

PRODUCTION AND STORAGE OF SPORES

For successful inoculation of rice plants with the blast fungus, it is important that the inoculum have a high spore content (Goto *et al.*, 1961). Actual concentration of spores needed differs with the fungus isolates and also, perhaps, with the growth condition of the inoculated plants. A procedure adopted at the Academia Sinica has been proved satisfactory for producing blast spores. Barley seeds (10 g) were mixed with 12 ml of water in a 125 ml flask and, after standing for 1–2 hours, sterilized in an autoclave. As soon as the flask cooled to room temperature, inoculation was made, and the inoculated flasks were kept at 26 C in an incubator for 3–4 days. During this period, the mycelium started to spread. The flasks were then shaken, to break down the mycelium, and returned to the incubator for another 3–4 days. Usually a full development of mycelium could be obtained in one week under these conditions. The barley seeds were then washed with sterilized water to remove the surface mycelium and transferred to a petri dish layered with filter paper. The petri dishes containing the seeds were covered halfway and laid on a laboratory bench, preferably near a window. A large quantity of spores usually appeared in 2–3 days. Wheat, rice, sorghum, and green beans were found less suitable than barley for this purpose, according to Kou (unpublished).

To be stored for later use, the barley seeds with abundant spores could be air-dried, packed in plastic sacks, and kept under refrigeration. Kou reports that spores so stored for more than eight months gave 85 per cent germination and did not change in pathogenicity.

At TARI, the yeast starch medium (yeast extract, 2 g; soluble starch, 10 g; agar, 17 g; water, 1,000 ml) has been found more satisfactory for the sporulation of the blast fungus than 12 other agar media. The length of time required for the fungus to reach maximum spore formation at 27 C in tube culture varied from one week in most cases to three weeks with some isolates. Spores harvested from tube culture were used to inoculate 25 ml of yeast starch medium in a flat bottle. Five ml of the spore suspension was used for each bottle. Spores for plant inoculation were collected by washing the content with distilled water after 5–7 days of incubation at 27 C. Autoclaved rice grains in a flask were used as a substitute for the agar medium, but this was done less frequently and usually with isolates that failed to produce a large number of spores on the yeast starch agar. Aeration was employed following the method of Andersen and Henry (1948).

INOCULATION

Rice seedlings employed for race identification at the Academia Sinica were grown in 4-inch pots and at TARI in paint-coated metal boxes 7 x 7 x 10 cm3 in size, usually with 10 plants per pot or box. Inoculation procedure in the two institutions was similar. Test plants at the 3- to 5-leaf stage were inoculated by spraying the spore suspension onto the leaves. The final spore concentration reached in the inocula varied with isolates and the way of growing fungus. In both institutions, generally, inoculum having a spore concentration of 10–20 spores per low-power microscopic field (100–150 $\times$) was used. This was equivalent to a concentration of 50,000–100,000 spores per ml. After inoculation, the plants were kept for 14–20 hours under a polyethylene sheet on a wooden frame, where the humidity was maintained at the saturation point. The temperature in the greenhouse for plant growth and symptom expression varied from about 10 to 35 C. Most inoculation work was done at a temperature ranging from 24 to 32 C. Plant reactions were read 4–9 days after inoculation, depending on the environmental conditions. To reduce possible mis-

identification, three simultaneous groups of differential varieties were inoculated at TARI. At the Academia Sinica, three replications for each test were provided by using three duplicated groups of differential varieties at different times.

GROUPING OF INFECTION TYPES

In studying rice varietal reaction to blast in Taiwan, Hashioka (1950a) adopted a system of grouping the infection types into five categories designated as A, B, C, D, and E. Other systems (see chap. 12) have since been proposed by various workers (Abumiya, 1955; Latterell, Tullis, and Collier, 1960; Goto *et al.*, 1961). In early work on the physiologic races of *Piricularia oryzae* at TARI, reaction types were classified as I, R, M, and S denoting immune, resistant, intermediate, and susceptible, respectively (Hung and Chien, 1961; Hung, Chien, and Lin, 1961). The symbol I was later dropped and the absence of lesion response was also taken as R. At the Academia Sinica, infection types were simply recognized as R and S to signify resistant and susceptible reactions. These systems for grouping infection types are compared with others in Table 15–2.

RACE IDENTIFICATION AT TARI

DIFFERENTIAL VARIETIES EMPLOYED

The selection of the 16 differential varieties now in use was done by the late H. C. Li (1957), who pioneered the race study in Taiwan. In 1957, 28 varieties were first selected, 8 from rice collections then available at TARI, and 20 from a group of 28 varieties which were entered into the Uniform Blast Nurseries in 1956. Upon further screening, the 16 varieties listed in Table 15–3 finally were chosen. These include 11 varieties of the *japonica* type and five of the *indica* type. Of the *japonica* group, one was introduced from mainland China, three from Japan, and seven were bred locally. Of the *indica* group, two were upland rice and three were lowland rice.

RACES IDENTIFIED AT TARI DURING 1960–62

Hung, Chien, and Lin (1961) tested six isolates of *Piricularia oryzae* on the 16 rice varieties. Grouping by reaction types, they were able to differentiate the isolates into four groups (A, B, D, and E, according to their designation), each containing one single isolate, and also a fifth group (C) containing two isolates. Except group C, which could be equivalent to K in Table 15–4 below, none of these has been encountered in later determinations for unknown reasons.

Using the same set of differential varieties, tests were later made by C. C. Chien and S. Y. Lin, co-writers of this chapter, with 67 isolates collected in 1960, 141 isolates in 1961, and 99 isolates in 1962. The majority of these isolates were obtained from diseased materials collected in the blast nurseries situated in Ilan, Tungshih, Chiayi, Pingtung and, for 1962 only, also in Kwangshan. All inoculations were preceded by single spore isolation. Therefore, the existence of two or more races in the inoculum seemed unlikely, if variants did not arise after purification by single spore isolation. For each identification, three simultaneous replications were provided. Table 15–4 summarizes the results. The 19 races obtained can be conveniently arranged into seven race groups as follows:

Group A: Isolates of this group containing one single race (race 1) either were avirulent or had only weak pathogenicity to incite resistant reaction in the 16 differential varieties under experimental conditions. Apparently the isolates of this group might have lost their pathogenicity upon culturing. Several of them originally were obtained from leaf lesions of susceptible type in one of the differential varieties.

Group K: Isolates that constituted this monoracial (race 2) group caused susceptible

TABLE 15–2: Systems for Grouping Blast Infection Types in Taiwan as Compared to Systems Adopted Elsewhere

Infection type	Designation				
	TARI		Academia Sinica	Goto *et al.*, 1961	Latterell *et al.*, 1960
	1958–59	1960–62			
No lesion response	I	R	R	HR	0
Brown to dark brown small spots devoid of a gray center, usually 1 mm in diameter	R	R	R	R	1–2
Brown to purple spots with gray center, about 2 mm in diameter	M	M	R	RS	3
Rapidly expanding lesions of medium to large size, usually with water-soaked appearance at first, and purplish brown border and gray center later	S	S	S	MS S	4–5

TABLE 15–3: Sixteen Rice Varieties Employed at TARI as Differentials for Identification of Physiologic Races of the Blast Fungus

Variety [a]	Type	Origin
Kung-shan-wu-shen-ken	*Japonica*, lowland	Mainland China
Taichung 65	*Japonica*, lowland	Taiwan
Pai-kan-tao	*Japonica*, lowland	Taiwan
Taichung 171	*Japonica*, lowland	Taiwan
Chianung 242	*Japonica*, lowland	Taiwan
Kwang-fu 1	*Japonica*, lowland	Taiwan
Chianung 280	*Japonica*, lowland	Taiwan
Taichung line 33	*Japonica*, lowland	Taiwan
Kanto 51	*Japonica*, lowland	Japan
Norin 21	*Japonica*, lowland	Japan
Sensho	*Japonica*, lowland	Japan
Cutsugulcul	*Indica*, upland	Taiwan
Natala	*Indica*, upland	Taiwan
Kao-chio-liu-chou	*Indica*, lowland	Taiwan
Kaohsiung-ta-li-chen-yu	*Indica*, lowland	Taiwan
Taichung-ti-chio-wu-chien	*Indica*, lowland	Taiwan

[a] Grouping of the differential varieties is based on records kept at TARI.

leaf lesions only in the variety Kung-shan-wu-shen-ken. No infection or only resistant leaf lesions were induced in other varieties. This race group also contained isolates obtained from susceptible lesions in differential varieties other than Kung-shan-wu-shen-ken.

Group N: This group was represented only by a few isolates of race 3 which caused susceptible lesions in the *indica* variety Natala but resistant reaction in other differential varieties. One isolate originating from a susceptible lesion in Taichung 65 failed to induce susceptible reaction in this variety upon testing.

Group J: Isolates of four races (4, 5, 6, and 7) that constituted this group produced susceptible leaf lesions in Kung-shan-wu-shen-ken as well as in the two upland *indica* varieties. Lesions of susceptible or intermediate types were induced in the three *japonica* varieties from Japan. Reactions in other differential varieties differed with races.

Group I: This group also was composed of four races (8, 9, 10, and 11) which produced susceptible leaf lesions in the three

local varieties of lowland *indica* rice, but, resistant reaction in Kung-shan-wu-shen-ken. All or most of the locally developed *japonica* rice varieties responded with resistant reactions.

Group P: Five races (12, 13, 14, 15, and 16) were taken under this group for their susceptible type lesions in Kung-shan-wu-shen-ken and the seven locally developed *japonica* varieties. The variety Natala from which Taichung line 33 derived its blast resistance also gave susceptible response to these five races. Race 12 of this group was the most virulent one among the 19 races so far recognized. It produced susceptible leaf lesions in all 16 differential varieties.

Group X: This was apparently a highly heterogeneous race group composed of three races (17, 18, and 19) having few pathogenic properties in common. Susceptible reaction was produced by isolates of the three races in Kung-shan-wu-shen-ken and Taichung 65.

Chang (1962) mentioned briefly the results of testing 56 monoconidial isolates collected in 1960 and earlier. Seven major race groups were recognized at that time. The grouping system has later been revised and some races have been reclassified, as shown in Table 15–4.

REGIONAL DISTRIBUTION PATTERN OF RACES

To obtain a representative geographical distribution of the physiologic races of a pathogenic fungus and its changes, in which race investigators and plant breeders are greatly interested, one should analyze a large number of fungus collections. The rather limited number of isolates of the blast fungus tested at TARI in the past did not permit a reliable determination of the race distribution pattern and its changes on a yearly basis. Combined data obtained during 1960–62, presented in Fig. 15–1, give an idea of the relative prevalence of the 19 races in the five locations over the three-year period.

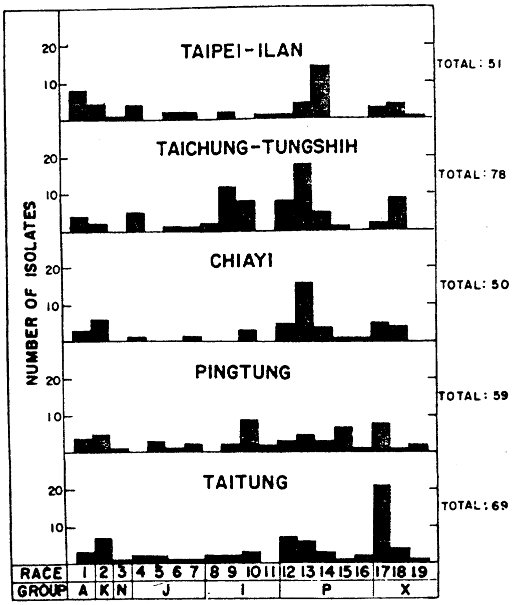


FIG. 15–1: Distribution of *Piricularia oryzae* races in Taiwan.

It is evident from this figure that races 13, 14, and 17 were the most predominant ones. Most frequently encountered was race 13, which attacked all 16 differential varieties, except three of Japanese origin. It must be pointed out that the regional distribution pattern of the 19 races, as shown in Fig. 15–1, might not reflect the race pattern prevailing in the commercial rice fields in the five locations. Collections of the fungus were obtained largely from blast nurseries where experimental rice lines instead of commercial varieties were grown.

RACE IDENTIFICATION AT THE ACADEMIA SINICA

Nine varieties, all of the *japonica* type, have been selected as differentials at the Academia Sinica. Five physiologic races, shown in Table 15–5, were recognized from a total of 40 single spore isolates collected from various rice growing areas in 1961 (Kou, Woo, and Wang, 1963). The race list

TABLE 15–4: Physiologic Races of *Piricularia oryzae* Identified at TARI during 1960–62

Differential variety	Race designation																		
	A	K	N			J				I				P				X	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Kung-shan-wu-shen-ken	R	S	R	S	S	S	S	R	R	R	R	S	S	S	S	S	S	S	S
Taichung 65	R	R	R	R	S(m)	S	R	R	R	R	R	S	S	S	S	S	S	S	S
Pai-kan-tao	R	R	R	R	M(r)	S	R	R	R(s)	R	S	S	S	S(m)	S(r)	S	R	S	R
Taichung 171	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	S	R	R	S
Chianung 242	R	R	R	R	R	S	R	S	R	R	R	S	S	S	S	S	R	R	S
Kwang-fu 1																			
Chianung 280	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	S	R	R	R
Taichung line 33																			
Kanto 51	R	R	R	S	M	S	S	R	R	R	R	S	R	S(r)	R	S	R	R	S
Norin 21	R	R	R	S	M	S	S	S	R	R	R	S	R	S	R	S	R	R	R
Sensho	R	R	R	S	M	S	S	S	R	S	S	S	R	S(m)	M	S	R	R	R
Cutsugulcul	R	R	R	S(m)	S	S	S	R	R	R	S	S(m)	S	S(r)	R	S	R	R	R
Natala	R	R	S	S	S	S	S	S(m)	S	S	R	S(m)	S(m)	S	S	S	R	S(m)	S(m)
Kao-chio-liu-chou	R	R	R	R	S(m)	S	S(m)	S	S(r)	S	S	S	S	S	R	R	R	R	R
Kaohsiung-ta-li-chen-yu	R	R	R	R	M	S	S(m)	S	S	S	S	S	S	S(r)	R	R	R	R	R
Taichung-ti-chio-wu-chien	R	R	R	S(m)	R	S(m)	S(m)	S	S	S	S	S	S	M	R	R	R	S	R
Number of isolates identified																			
1960	4	2	1	2	0	0	0	4	3	4	0	11	15	3	6	0	10	0	2
1961	10	9	0	6	0	0	0	0	13	13	0	7	26	23	4	0	17	11	2
1962	8	13	2	4	5	5	7	0	2	6	3	6	8	3	0	4	12	11	0

Small letters in parentheses denote minor infection on types observed in inoculated plants.

TABLE 15–5: Physiologic Races of *Piricularia oryzae* Identified at the Academia Sinica

Differential variety	Race and isolates[a]				
	1 6f, 6g, 6e, 8a, 8d, 11a, 11c	2 1a, 1b, 1c, 1d, 1f, 1g, 1e, 10a, 10b	3 2a, 2b, 2c, 8c, 8f, 9a, 9b, 9c, 9d, 9e, 9f	4 2d, 2e, 2f, 2g, 8b	5 3b, 3c, 3d, 3e, 5b, 5c, 5d, 5e
Kwang-fu 401 Taichung Special 6 Hsinchu 50	R	R	R	R	S
Chianan 8 Taichung 178	S	S	S	R	S
Chianung 242	S	R	S	S	R
Chianung 280	R	R	S	R	R
Pai-kan-tao	R	R	R	R	R
Taichung 65	S	S	S	S	S

SOURCE: Kou, Woo, and Wang (1963)
[a] Numerals represent collections; small letters represent the single conidium.

has been expanded with three recent additions identified from collections made in 1962, according to Wang (unpublished). Since the set of differentials employed at the Academia Sinica includes only four varieties—Pai-kan-tao, Chianung 280, Chianung 242, and Taichung 65—which are differentials also employed at TARI, results from the two institutions could not be compared adequately. Evidence indicates, however, that the 19 races, except races 5, 17, and 19 identified at TARI, were not among the first five races identified at the Academia Sinica.

Of the nine differential varieties, Kwang-fu 401, Taichung Special 6, and Hsinchu 50 are generally known as susceptible, while Chianung 242 is resistant. The detection of races 1, 3, and 4, which induced a resistant reaction in the first three but a susceptible reaction in Chianung 242, is interesting though not unexpected.

CULTURAL AND PATHOGENIC STABILITY OF RACES

Various workers have shown repeatedly that the blast fungus undergoes changes easily on successive mycelial transfers to produce variants which may differ from the parental type in cultural behavior. Variations resulting in loss of pathogenicity also have been observed frequently. These phenomena make the maintenance of the blast fungus difficult, and undoubtedly complicate the race study.

Work undertaken at TARI also included attempts to differentiate races to see whether isolates of some blast races could be kept through single spore generations without a considerable change in their cultural and pathogenic characteristics. Five single spore isolates—OS-45S, 1Ta-5S, 1I-31N, 1S-5S, 2S-55S, representing four races—were carried through six to eleven asexual generations on yeast starch agar. One tube of each of the five isolates resulting from a single spore was designated as zero asexual generation, A_0. From this, usually 30 spores were taken singly and subcultured. The tubes thus obtained were recorded for their colony morphology. They were grouped as parental type if the tube resembled the original culture, and as variant if the tube differed from the original. Then, from this first asexual generation (A_1), about 30 single spores each were taken at random from the parental type and the variants, and analyzed as before. The process was repeated at later generations. The results are summarized as follows:

Isolate OS-45S produced one variant which constituted about 55 percent of the

total 625 single spore cultures in eleven generations. The parental type was characterized by the formation of a dark gray colony with concentric zonations on yeast starch agar. It produced abundant spores in about one week. The variant had tufty white mycelial masses layering over the grayish colony with less conspicuous zoning. Spores were produced in greater amount. Both the parental type and the variant continued to segregate into the two culturally distinctive types up to the eleventh or last generation in the experiment.

Isolate 1Ta-5S produced a grayish white colony with a large amount of coarse aerial hyphae. Upon single spore transferring, it segregated into the parental type, one stable variant, and one unstable intermediate type. The stable variant produced a gray colony and the intermediate had sectors of both parental type and variant. The parental type continued to yield variant or intermediate colonies up to the fifth generation. The variant and the intermediate did not change back to the parental type.

Isolate 1S-5S had a white colony. Upon the first four successive single spore transfers, it produced in low frequency one variant which had whitish gray aerial hyphae and a greater number of spores. The variant tended to change back easily to the parental type upon transferring. At the fifth and sixth generations, only the parental type was obtained.

Isolate 1I-31N had a gray colony with moderate spore formation. In the first asexual generation, it gave the parental type and a variant. The variant produced white aerial hyphae and sporulated sparingly. Spores from both types exhibited a greater tendency to develop into the variant. Finally, the variant became the predominant cultural type among the single spore progenies. All single spore cultures at the fifth and sixth generations were of the variant type.

The fifth isolate, 2S-55S, had a grayish white colony and was carried for six single spore generations with no obvious change in cultural characteristics.

The asexual progenies of these five isolates were also tested for their pathogenicity at each asexual generation. The points of interest are whether the subcultures by single spore transferring induce the same host reactions as the stock cultures, and, if variants arise, whether the parental type and the variants are pathogenically identical. One to five single spore subcultures, each representing the parental type or the variants, were studied. The 16 differential varieties were employed for this purpose.

It was found that the ability to retain pathogenicity differed with the isolates. Three isolates—I1-31N, 1S-5S, and 2S-55S—did not change in their pathogenicity through succesive single spore cultivations despite the fact that a change in their cultural characteristics was noticed in the first two generations. With OS-45S and 1Ta-5S, the cultural variants had pathogenic properties, suggesting that they belong to different races from the original cultures (see Table 15–6). Thus, the parental type of isolate OS-45S was identified as race 13, and the variant as race 15. With 1Ta-5S, both the parental and intermediate types were identified as race 13, whereas the stable variant was identified as race 10. In these cases, a gain in

TABLE 15–6: Stability of Pathogenicity of Isolates upon Successive Single Spore Cultures

Isolate	Asexual generations studied	Race identification		
		Parental type	Intermediate type	Cultural variant
OS–45S	A_1–A_{10}	13		15
1Ta–5S	A_1–A_5	13	13	10
1I–31N	A_1–A_6	14		14
1S–5S	A_1–A_6	12		12
2S–55S	A_1–A_6	10		10

pathogenicity with respect to one host and a loss with respect to another variety were noticed.

The pathogenicity of races of the blast fungus, after passing through host varieties, was tested at the Academia Sinica (Kou, Woo, and Wang, 1963). Two culturally stable isolates, 1f and 9a representing two races, were first inoculated to eight and four varieties respectively. Lesions of either R or S type were produced in inoculated plants. Re-isolates were obtained from the lesions and tested for their reaction in twelve varieties. The original cultures, stored as dry spores, were included as control. It was found in this experiment that the two isolates did not change in their pathogenicity upon passage through any of the twelve varieties employed.

RACE IDENTIFICATION WITH DIFFERENTIALS EMPLOYED IN JAPAN AND THE UNITED STATES

A comparison of the physiologic races of the blast fungus identified in Taiwan with those identified in other countries is of great interest since varieties known as susceptible locally give a resistant reaction elsewhere (IRRI Annual Report, 1961–1962). It is impossible to base such comparisons on the experimental data in the literature, however, because different groups of differentials are used for race identification. One possible approach to this problem, without involving the risk of introducing new races, is to test the local races on differential varieties employed in other countries. In a limited experiment conducted at the Academia Sinica, two isolates each of races 1 and 3, and one isolate each of races 2 and 5, were inoculated to eight differential varieties employed by Yamanaka in Japan in 1957 (Kou, Woo, and Wang, 1963). The two isolates of race 1 induced non-identical reactions in the differentials from Japan. The same also was true with the two isolates of race 3. None of the test isolates could be classified under any of the ten races identified by Yamanaka. These results should not be taken as conclusive evidence that the races present in Japan do not exist in Taiwan because of the rather small number of the isolates used in the comparison and the possible change in varietal reaction caused by environmental changes.

Using the American set of differentials, 12 isolates of the blast fungus from Taiwan have been tested by Latterell.[4] Six isolates were classified as race 4, two as race 3, and one each as races 2, 18, 20, and 21.

DISCUSSION

In the study of physiologic races of blast fungus, it is usually assumed that the result of inoculation with a given isolate is reproducible, if environmental conditions are kept constant. Reproducibility could be high with the more stable isolates of the blast fungus but low with the less stable ones. According to Kozaka *et al.* (1962), most blast isolates gave the same identification as they did in a previous year, but some exhibited a changing pathogenicity. Thus, one isolate shifted from race group N to group C, marking a gain in its pathogenicity. Another isolate shifted from race group C to group O as a result of pathogenicity loss. Goto and Yamanaka (1958) also reported the appearance of a new race with greater pathogenicity than the original culture. In successive single spore cultures carried out at TARI, the rise of new races from single spore isolates also was observed. Although all five isolates under study retained their original pathogenicity in their asexual progenies up to the fifth or tenth generation, two isolates continued to give rise to cultural variants which also differed from the parental types in their pathogenicity to certain host varieties. Variation of this kind makes consistent results of race identification less probable with some unstable isolates, especially if the fungus is

[4] Personal communication from T. H. Barksdale, 1962.

maintained on culture media. Variation also makes it difficult to distinguish among races that exist naturally and those that arise during the testing process. Therefore, the results of race identification based on host reactions must be interpreted with caution.

The studies of physiologic specialization of *Piricularia oryzae* under review have established that different physiologic races of the fungus do exist in Taiwan. It remains to be determined, however, whether all those 19 races identified at TARI and the 8 races identified at the Academia Sinica represent the races that occur naturally in the field. In view of the great complexity of rice varietal composition in Taiwan and the number of differentials employed for race identification, a complex race pattern as obtained at TARI is to be expected. This does not exclude the possibility, however, that a few minor races, race 3 for instance, might actually arise as a result of pathogenicity loss during culturing. These races contained isolates which were virulent to some of the differential varieties under field conditions, but were avirulent in the greenhouse.

Of the 16 differential varieties employed at TARI, several are being utilized as resistance sources in the present rice breeding program (Ou and Lin, 1958; Chang, 1962). The detection of race 12, which attacks all 16 differentials, makes these resistance sources inadequate for the purpose. This finding also indicates the need for replacement with—or addition of—some more suitable differential varieties for future race studies in Taiwan, especially in view of the fact that the elimination of varieties Kwang-fu 1 and Taichung line 33 (or, alternatively, elimination of Chianung 242 and Chianung 280) from the differential list would not affect race identification. The need for varietal replacement also may occur with the present set of differentials employed at the Academia Sinica.

稻熱病菌對水銀離子耐性之研究*

簡 錦 忠

一、前 言

近年來本省對於稻熱病之研究工作已逐漸加強，並獲悉省內之稻熱病菌有 10 餘種不同生理型之存在[1]。又在田間應用有機汞劑類之殺菌劑對該病已得優良之防治效果。但多年連續施用水銀劑之影響，將來可能出現變異性之耐藥菌系。關於此項研究，據 J. J. Christensen[2] 之報告，*Gibberella zeae* 在含有 malachite green, ethyl mercuric phosphate，等培養基上繼代培養時，該菌對此等藥劑漸呈抵抗性，又山崎氏[5]等對稻熱病菌與硫酸銅，硼酸亦有同樣之報告。且吉井氏[8,9,10] 等曾提出稻熱病菌對 phenyl mercuric acetate 之耐性報告。本研究係爲探討本省稻熱病菌對汞劑耐性產生與否而作此試驗。

本研究進行時，得鍾順昌先生之協助，文成蒙臺灣大學陳教授其昌校閱，均此一併謹誌謝忱。

二、試驗材料與方法

I 供試材料：

(1) 供試病菌：稻熱病菌 (*Piricularia oryzae* Cav.) 係本系保存，致病力強之 0S–45S 菌號（對16種判別稻種均呈感病性病斑）及致病力弱之 1C–32S 菌號（僅對16判別稻種中之崑山五香糯及臺中65號兩品種呈感病性病斑）。

(2) 供試水銀離子：$HgCl_2$

(3) 基礎培養基：馬鈴薯煎汁洋菜培養基 (P. S. A.)。

II 方 法：

將基礎培養基（馬鈴薯 200 g, 洋菜 18 g, 蒸餾水 1000 cc, 蔗糖 20 g），加注不同濃度之 $HgCl_2$（最低濃度自 0.018 mM 開始，分爲五階段，每階段增加 0.025～0.032 mM 之濃度），然後倒入培養瓶內（每瓶 20 cc.），待凝固後，接種稻熱病菌之小菌絲塊，並放置於 28°C 定溫箱內，經過一定時間後觀察各處理之菌落色澤，形態及生長速度等性質，二週後作最後之觀察。測定該菌在水銀離子下之可能生長濃度，同時另以無加水銀離子之馬鈴薯培養基爲對照，並比較兩生理型之病菌對水銀離子耐性之差異。

根據上述測定之結果，判定其可能生長之最高濃度之菌落爲次代之接種源，並以此濃度爲最低濃度，分爲五階段與對照比較，如此連續進行測定試驗，至最高耐性濃度之確定爲止。以探討 *P. oryzae* 在不同濃度之水銀離子上連續培養及獲得耐性之程度。再將耐性菌及正常菌於溫室內舉行接種試驗。根據本研究室鑑定稻熱病菌生理小種之方法，於 16 判別稻種上，測定其感病反應之差異。

三、結 果 及 討 論

A 兩種不同生理小種之稻熱病菌對水銀離子之自然抵抗性：

未曾與藥劑接觸過之病原菌，對於該藥劑本來就具有之抵抗性，稱之爲自然抵抗性。而一般由田間採集之病原菌，直接測定其對藥劑可能生長之界限濃度爲自然抵抗性，實際上因田間藥劑防治之結果，田間直接採得之菌種，其對藥劑之抵抗性可能已受藥劑之影響。本試驗所供試之菌系，係

*本研究之完成得國家長期發展科學委員會之補助。

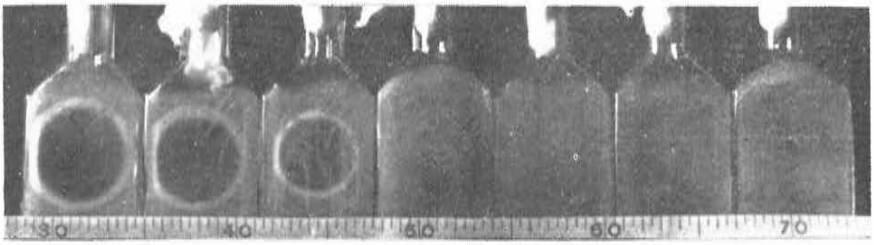
本系稻熱病菌生理小種研究室，由全省各地直接採集，經單胞純系分離及連續培養保存者。如表一，致病力強之生理小種 (0S～45S) 其自然抵抗性爲 0.05 mM (圖一)；致病力弱之生理小種 (1C-32S) 爲 0.082mM (圖一)。

表一　不同濃度之水銀離子對稻熱病菌兩菌絲生長之影響

Table 1. The natural resistance of two different physiologic races of *P. oryzae* against mercuric chloride

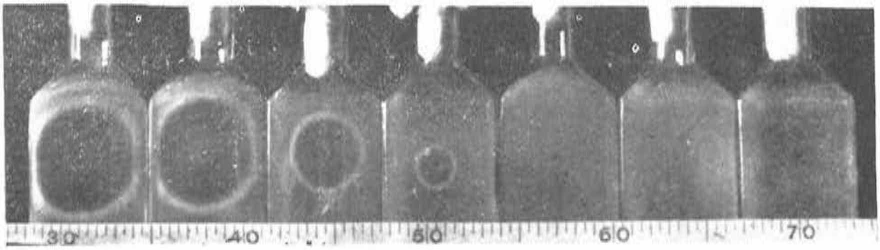
菌落直徑 (mm) / $HgCl_2$ 濃度 (mM) / 菌株	0.018	0.050	0.082	0.114	0.146	0.178	CK
0S-45S	44	36	—	—	—	—	48
1C-32S	56	30	16	—	—	—	56

註：接種後第10天之調查記錄。



CK　0.018　0.050　0.082　0.114　0.146　0.178 mM

0S-45S



CK　0.018　0.050　0.082　0.114　0.146　0.178 mM

1C-32S

圖一　不同濃度之水銀離子對稻熱病菌兩菌絲生長之影響

Figure 1. The natural resistance of two different physiologic races of *P. oryzae* against mercuric chloride

B　兩種不同生理小種之稻熱病菌對水銀離子耐性之增強：

爲測定稻熱病菌在田間是否對水銀離子具有耐性之增強，事先在實驗室內檢討其耐性增強之可能性是必然的。本試驗以 P. S. A. 爲基本培養基，注入數種不同濃度之昇汞，以測定自然抵抗性所得 0.050 mM 之致病力強菌絲及 0.082 mM 之致病力弱菌絲爲接種源。經培養測定後，以其最高濃度生長之菌絲爲次一系列水銀離子培養基之接種源，每兩週爲一代連續培養結果如表二。兩種生理小種顯示不規則之耐性增強，漸次由 0.050 或 0.082 mM 達 0.375 mM。

如表二，數代連續培養試驗之結果，稻熱病菌對水銀離子，顯示不規則之耐性增強，每一代之增強由 0.025 mM 至 0.100 mM 不等。耐性之增加每代逐漸減少，第六代達 0.375 mM 後，兩生理小種都達最高耐性，連續再培養四代其耐性卽不增加，亦無減低之趨勢，乃保持於 0.375 mM

表二 兩種不同生理小種之稻熱病菌對水銀離子耐性增強之情形

Table 2. Increasing drug resistance of two different physiologic races of *P. oryzae* against mercuric chloride.

代數	菌株 ＼ 菌落直徑 (mm) ＼ $HgCl_2$ 濃度 (mM)	0.034	0.050	0.066	0.082	0.098	0.114	0.125	0.150	0.175	0.200
1	0S-45S	40	32	26	22	16	⑧	—	—	—	—
2							40	36	32	26	16
3											24
4											
5											
6											
7											
8											
9											
10											
1	1C-32S			36	24	18	⑫	—	—	—	—
2						42	32	24	18	12	⑥
3											12
4											
5											
6											
7											
8											
9											
10											

代數	菌株 ＼ 菌落直徑 (mm) ＼ $HgCl_2$ 濃度 (mM)	0.225	0.250	0.275	0.300	0.325	0.350	0.375	0.400	CK_x	CK
1	0S-45S	—								48	48
2		④	—	—	—	—				56	56
3		6	②	—	—	—	—	—		60	60
4			66	62	(52)	—	—	—	—	66	68
5					10	④	—	—	—	62	70
6						20	12	⑧	—	68	72
7								⑧	—	60	60
8								⑩	—	62	66
9								⑥	—	62	66
10								⑧	—	60	62
1	1C-32S	—	—							54	54
2		—	—	—	—	—				56	56
3		10	6	②	—	—	—	—		56	56
4				66	(60)	—	—	—		66	68
5					10	④	—	—	—	66	70
6						20	16	⑫	—	64	68
7								⑩	—	60	60
8								⑩	—	60	60
9								⑩	—	64	66
10								⑩	—	66	66

註：1. CK：示正常菌之對照處理。
2. CK_x：示耐藥菌之對照處理。
3. ○：示下代之接種源。

之濃度上。各處理之菌落色澤，形態均與未經藥劑處理之對照相同，只是生長速度每代均有變化，此因受藥劑濃度之抑制外，天然培養基養分之差異亦有密切關係。

C　兩種不同生理小種之稻熱病菌對水銀離子耐性之持續：

水銀離子耐性菌於基礎培養基（無藥劑）上作復元培養試驗，以觀察耐性持續之有無。山崎等曾將硫酸銅耐性之稻熱病菌以無硫酸銅培養基作數代之復元培養，其耐性稍爲降落，但不能復元。本試驗第一代 (0.114 mM) 耐性菌在無水銀離子之基礎培養基上，以二週爲一代，連續測定其耐性之程度。經10代之結果如表三。

表三　第一代 (0.114 mM) 耐性菌與其每代復元菌在不同濃度之水銀離子培養基之發育比較

Table 3. The mycelial growth of 0.114 mM resistant culture and each of its recovered stage.

菌株		$HgCl_2$ 濃度 (mM)	0.05	0.10	0.150	0.200	0.250	CK_x	CK
0S-45S	0.114 mM 耐藥菌		+++	++	+	+	−	+++	+++
	復元菌代數 Stage of recovered culture	1	+++	++	+	+	−	+++	+++
		2	+++	++	+	+	−	+++	+++
		3	+++	++	+	+	−	+++	+++
		4	+++	++	+	+	−	+++	+++
		5	+++	++	+	+	−	+++	+++
		6	+++	++	÷	+	−	+++	+++
		7	+++	++	+	+	−	+++	+++
		8	+++	++	+	+	−	+++	+++
		9	+++	++	+	+	−	+++	+++
		10	+++	++	+	+	−	+++	+++
1C-32S	0.114 mM 耐藥菌		+++	++	+	+	−	+++	+++
	復元菌代數 Stage of recovered culture	1	+++	++	+	+	−	+++	+++
		2	+++	++	+	+	−	+++	+++
		3	+++	++	+	+	−	+++	+++
		4	+++	++	+	+	−	+++	+++
		5	+++	++	+	+	−	+++	+++
		6	+++	++	+	+	−	+++	+++
		7	+++	++	+	+	−	+++	+++
		8	+++	++	+	+	−	+++	+++
		9	+++	++	+	+	−	+++	+++
		10	+++	++	+	+	−	+++	+++

註：1. 復元菌供於第一次耐性測定者來自 0.114 mM 耐藥菌在無水銀離子之基礎培養基上（CK_x）生長者，第二次者來自第一次 CK_x，第三次者來自第二次 CK_x，以下類推。

2. ＋：示發育良；　±：示發育不良；　−：示無生長。

3. 接種後第十天之調查記錄。

據表三顯示稻熱病菌，經連續復元培養其對水銀離子之耐性均無變化。在此試驗範圍內爲永續性，其機構如何，值得更進一步之研究。

D　耐藥菌與正常菌之病原性比較：

利用本研究室研究稻熱病病原菌生理小種之設備，判別稻品種及方法，測定耐藥菌及正常菌在

16判別稻品種上之感病反應，並與未經處理母菌比較其病原性之差異。其結果如表四。

表四　未處理之母菌與處理後之耐藥菌及正常菌對16判別稻品種上之感病反應

Table 4. Comparing the disease reactions of 16 different rice varieties to the drug resistant cultures with to normal 10-stages cultures and to morther culture.

菌株 / 稻品種	0S-45S			1C-32S			備考
	母菌	耐藥菌	正常菌	母菌	耐藥菌	正常菌	
崑山五香粳	S	S	S	S	S	S	
臺中65號	S	S	S	S	S	R	
稗稈稻	S	S	R	R	R	R	
臺中171號	S	S	R	R	S	R	
嘉農242號	S	S	S	R	S	S	
光復1號	S	S	S	R	S	S	
嘉農育280號	S	S	R	R	S	R	
臺中系比33號	S	S	R	R	S	R	
關東51號	R	R	R	R	R	R	
農林21號	R	R	R	R	R	R	
Sensho	R	R	R	R	R	R	
Cutsugulcule	S	S	S	R	R	R	
Natala	S	S	S	R	S	S	
高脚柳州	S	S	S	R	R	R	
高雄大粒清油	S	S	S	R	R	R	
臺中低脚烏尖	S	S	S	R	R	R	

據表四得知，經10代連續培養之正常菌與$HgCl_2$不同濃度之培養基連續培養所得耐藥菌，其病原性似有顯著變化。據本試驗結果，致病力強及弱之兩菌株，耐藥菌之病原性都強於正常菌。一般病原菌經培養基上連續培養後，其病原性均有退化現象，但經藥劑處理之耐藥菌，都無此現象。如表四，致病力強之菌號 (0S-45S)，耐藥菌在16稻品種上之感病反應與母菌完全相同，而經連續培養10代之正常菌且有退化情形發現。致病力弱之菌株 (1C-32S)，耐藥菌之致病力強於對照處理之正常菌，但母菌之致病力反而差於處理後之菌種，此原因可能受試驗環境之差異所致或病原菌本身之變異現象，有更進一步探討之必要。

四、摘　　要

本試驗係於實驗室內探討兩種不同生理小種之稻熱病病原菌，由於連續施用水銀劑後是否可能產生變異性耐藥菌種而擧行，其結果簡述如下：

1. 致病力強之稻熱病菌生理小種，對 $HgCl_2$ 之自然抵抗性爲 0.050mM ，致病力弱之生理小種爲 0.082mM。

2. 供試兩生理小種對水銀離子顯示不規則之耐性增強。培養至第六代達 0.375mM 爲最高耐性。此後再連續培養四代，均未有增加耐性之趨勢。

3. 供試耐藥菌 (0.114 mM) 之兩種生理小種，連續培養於無藥劑之基本培養基內，其對水銀離子耐性之增加一致保持在 0.20 mM，似可認本菌對水銀離子具有永續耐性。

4. 根據處理前與處理後之菌種接種於16種稻品種上所呈現病斑之差異，測定其病原性之結果

，耐藥菌之病原性均强於連續培養後之正常菌，與處理前母菌之病原性比較，致病力强之生理小種耐藥菌與母菌完全相同，連續培養之正常菌且有退化現象。致病力弱之生理小種耐藥菌及正常菌均比母菌爲强。

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STUDIES ON THE DRUG RESISTANCE OF *PIRICULARIA ORYZAE* AGAINST MERCURIC CHLORIDE

by

C. C. Chien

ENGLISH SUMMARY

In order to determine the drug resistance of *Piricularia oryzae*, the rice blast fungus, against mercuric chloride ($HgCl_2$), two different physiologic races of *P. oryzae* were tested in this experiment. The results are summarized as follows:

(1) The natural drug resistance of 0S–45S, a strongly virulent race is at 0.05 mM; while 1C–32S, a weakly virulent race, at 0.082 mM.

(2) When the two different races of *P. oryzae* was cultured on the potato dextrose agar medium containing different concentrations of $HgCl_2$ for 6 stages (one stage is formed of 2 weeks culture). The fungus acquired the highest degree of drug resistance at 0.375 mM.

(3) Even if the drug resistant fungus at 0.114 mM is cultured on the normal medium containing no mercuric chloride for 10 stages (one stage is formed of 2 weeks culture), its resistance is not lost.

(4) Comparing the disease reactions of 16 differential rice varieties to the drug resistant cultures with to normal 10–stage cultures (successive cultivation on normal medium containing no mercuric chloride) of these two different races, the drug resistant cultures of both races are stronger in infectivity than normal 10–stage cultures of them. While compared with mother cultures, the drug resistant culture of 0S–45S race showed the same virulence as its mother culture, but the normal 10–stage culture became weaker in virulence. However, the drug resistant culture and normal 10–stage culture of 1C–32S race were more virulent than their mother culture.

PART I
STUDIES ON THE PHYSIOLOGIC RACES OF THE RICE BLAST FUNGUS, *PIRICULARIA ORYZAE* CAV.[1]

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Introduction

Since 1922-23, Sasaki (24) first reported the variation of pathogenicity in rice blast fungus, *Piricularia oryzae* Cav., many workers (13, 14, 17, 23, 25, 31) have studied the problems of physiologic specialization of the fungus in Japan. Classification of the fungus into physiologic types by comparing physiologic characteristics of isolates, and clarification of possible correlation between culture types and pathogenicity of the fungus were attempted (29, 30). Hemmi (16) intended to classify the fungus into strains by their pathogenicity to leaf and ear of rice. Suzuki (26) classified the races of the blast fungal isolates according to germination type of conidia and formation of appressoria. A joint study on the race problem under the leadership of Goto (8, 9, 10) was initiated in 1955, with five prefectural agricultural experiment stations participating.

In the United States, studies of different varietal reactions to the rice blast in separate geographic areas of the U.S. resulted in the discovery of physiologic races of *P. oryzae*, and the existence of at least two races of the fungus was reported (20). In further study, Latterel *et al.* (19) characterized fifteen physiologic races by their disease reactions on ten rice varieties. In 1963, they reported that 25 physiologic races had been characterized from the isolates obtained from 17 countries and from 5 rice growing areas of the United States on the basis of the differential reactions of 12 varieties of rice (18). Atkins (1, 3) reported the prevalence and distribution of physiologic races of *P. oryzae* in the U. S. and added one new race to the 15 existing races.

Field evidence indicating possible existence of physiologic races in Taiwan was first obtainted by Hashioka (11), who tested eight varieties for blast infection in seven locations and found a greater difference in varietal reaction due to locations than to yearly fluctuation. Li (21) observed differences in varietal reaction in blast nurseries established at four locations in 1956. This observation stimulated further research activities on the race problem. The study on physiologic race of the blast fungus was started in Taiwan Agricultural Research Institute in 1957, and in Academia Sinica, 1960. Hung *et al.* (12), using

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1. The authors are indebted to Drs. J. G. Atkins, C. R. Adair, F. M, Latterell, A. L. Robert, S. H. Ou, R. J. Chiu ,K. Goto and M. Yamada for their advice, and for providing cultures and rice seeds during the course of the investigation.

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16 differential rice varieties, recognized five pathogenic types among the seven isolates tested. Using the same set of differential varieties, tests were later made by Chien *et al.* with 67 isolates collected in 1960, 141 in 1961 and 146 in 1962. (6). They characterized these isolates into 19 physiologic races. These races were conveniently grouped into seven race groups characterized by their ability to infect certain groups of rice varieties. Successively six more races were identified by Chien and his co-workers (5). In Academia Sinica, another set of differentials was used for race characterization. In 1962, workers in Academia Sinica characterized 40 isolates into five physiologic races according to their virulence on the nine differentials (15).

Latterell *et al.* (18) suggested the need for superior differential varieties on an international basis and proposed 17 as possible candidates for a set of international differential varieties. In 1965 (4), a set of international differentials and nomenclature of races on an international basis by using the international differentials and standard techniques for uniform testing were proposed as the results of the United States-Japan Cooperative Rice Blast Project which was established in 1963.

In the course of cooperative efforts with the U.S.D.A., further characterization of races with isolates collected in Taiwan was made and the cultures of the blast races characterized by Chinese, Japanese and the U.S. workers were exchanged for investigation of their relationship. Several sets of differential rice varieties including U.S., Japanese differentials, 40 rice varieties from FAO, 24 tentative international differentials, 12 tentative international differentials, and 8 international differentials were tested as to their ability in differentiating isolates obtained in Taiwan, Japan and the U.S.

Materials and Methods

Isolation and maintenance of cultures

Isolations were made from the disease specimens collected during 1964-66 from the uniform blast nurseries. Pure cultures thus obtained were further subjected to single-spore transferring to yeast-starch agar slants. Stock cultures were maintained on rice straw medium in small test tubes and stored at 4° C.

Preparation of inoculum

Cultures to be tested for pathogenicity were first grown in 125 ml Erlenmeyer flasks containing 25 g water-soaked rice seeds and 10 ml water. After ten-day incubation at 28°C., the cultures were washed with sterilized water and removed to Petri dishes with their covers half open. Spores were produced abundantly in 3-6 days, depending on isolates. A second or third harvest of spores could be obtained by washing the cultures once or twice if they had not been contaminated.

Differential varieties

The 16 Taiwan differentials now in use for testing cultures of blast fungus and differentiating them into races are listed in Table 1. These include 11 varieties of the *japonica* type and five of the *indica* type. Of the *japonica* type, one was introduced from mainland China, three from Japan and seven were locally bred varieties. Of the *indica* type,

two are the upland rice and three the lowland rice (Table 1).

The U.S. differentials supplied by U.S. Army Biological Laboratory, Frederick, Maryland, the Japanese differentials by the Japan National Institute of Agricultural Science, the 40 rice varieties by FAO, the 24 tentative international differentials by IRRI and the 12 tentative international differentials by Dr. Atkins, U.S.D.A., the 8 international differentials by IRRI were used in the tests for their value in differentiating some representative Taiwan races of the blast fungus. The U.S. races kindly supplied by Dr. Atkins, and Japanese races by the Japan National Institute of Agricultural Science were used for testing their virulence to Taiwan differential varieties.

Table 1. Sixteen rice varieties employed at TARI as differentials for identification of physiologic races of *Piricularia oryzae* Cav.

Variety	Type	Origin
Kung-shan-wu-shen-ken	Japonica, lowland	Mainland, China
Taichung 65	〃	Taiwan
Pai-kan-tao	〃	〃
Taichung 171	〃	〃
Chianung 242	〃	〃
Kwang-fu 1	〃	〃
Chianung-yu 280	〃	〃
Taichung line 33	〃	〃
Kanto 51	〃	Japan
Norin 21	〃	〃
Sensho	〃	〃
Cutsugulcul	Indica, upland	Taiwan
Natala	〃	〃
Kao-chio-liu-chou	Indica, lowland	〃
Kaohsiung-ta-li-chen-yu	〃	〃
Taichung-ti-chio-wu-chien	〃	〃

Inoculation

The rice seeds sown for supplying test plants were treated with organic mercury fungicide and soaked in water for a few days at room temperature until they showed sign of germination. Plants were grown in paint-coated metal boxes (30cm × 30cm × 7.5cm in size), and placed on the greenhouse bench. Rice seedlings were top-dressed twice with 2% ammonium sulfate solution at the rate of 30 ml per box per application. Rice seedlings at the three to four-leaf stage were inoculated by spraying with spore suspension. Inoculated plants were incubated in a moist chamber of 20°–30°C for 24 hours before being removed to the greenhouse bench.

Recording of infection.

Five to seven days after inoculation, the inoculated plants were observed for reaction types which are classified as follows:

R (Resistant): Brown to dark brown small spots devoid of a grey center, usually 1 mm in diameter. The absence of lesion response also taken as R.

M (Moderately resistant): Brown to purple spots with grey center, about 2 mm in diameter.

S (Susceptible): Rapidly expanding lesions of medium to large size, usually with water-soaked appearance at first and a purplish brown border and a grey center later.

Experimental Results

1. Identification of races of P. oryzae Cav.

More than four hundred isolates of *P. oryzae* Cav. were obtained from the uniform blast nurseries in Ilan, Tungshu, Chiayi, Pingtung, Taitung, and Hualien areas during 1964-66, of which 293 isolates were tested on the 16 differential varieties and 19 races were characterized. Among them, 17 races showed the specialization pattern which had been previously detected (5). The addition of the two new races, races 26 and 27 increased the total number of races of the blast fungus to 27 races. These 27 races characterized during 1960-66 can be conveniently placed into seven race groups as follows:

Group A: Isolates of this group (race 1) were avirulent to the 16 differential varieties in greenhouse inoculation tests. They might have lost their pathogenicity during culturing, since most of them were originally isolated from leaf lesions of susceptible type.

Group K: Isolates of this race group (race 2 and 17) were characterized by their ability to infect KSWSK. In addition to their infectious ability to KSWSK, isolates of race 17 caused susceptible reaction on TC 65.

Group N: Isolates of this group (race 3) caused susceptible reaction on the *indica* variety Natala but resistant reaction on other differential varieties.

Group J: Four races (race 4, 5, 6, and 7) were included in this group. They were characterized by producing susceptible reactions on three *japonica type* varieties, (KT 51, NR 21 and SS). Reactions on other differential varieties were inconsistent.

Group I: This race group was composed of eight races (race 8, 9, 10, 11, 20, 21, 22, and 23). They were pathogenic to three local varieties of lowland *indica type* rice varieties.

Group P: Five races (race 12, 13, 14, 15, and 16) were placed under this group for their susceptible reaction on KSWSK and most of the locally developed *japonica* varieties. The variety Natala also gave susceptible reaction to the five races. Race 12 was the most virulent one among the 27 races so far characterized. It produced susceptible reaction on all 16 differential varieties.

Group T: Included in this race group were six races (race 18, 19, 24, 25, 26, and 27). This race group is characterized by its pathogenicity on KSWSK, TC 65 and

Natala.

The pattern of varietal reactions shown by the 27 races and the number of isolates obtained for each race during 1960-1966 are given in Table 2.

2. Prevalence and distribution of races of P. oryzae. Cav.

The distribution and frequency of occurrence of the 27 races of *P. oryzae* in Taiwan during 1964-66, together with those of 1960-63 are presented in Table 3 and Fig 1. Fig 2 gives the distribution of the blast races in Taiwan during 1960-66.

As shown in Table 3, races 24, 2 and 17 were the most predominant ones among 27 races during 1960-66. Race 13, the most predominant one during the years of 1960-63, and the major race in Tungshu and Chiayi areas, was not encountered during 1964-66, except one instance at Tungshu in 1966. On the other hand, only four isolates from four areas were designated as race 24 in 1963, however, it was encountered as many as 64 times during 1964-66. Races belonging to J group were not encountered in and after 1964. Races in P group, with the exception of race 12 which was encountered two times in 1964 and 3 times in 1965, of race 13 one time in 1966, and of race 16 one time in 1964, were not encountered in and after 1964. In I group, except race 9 which was characterized 3 times in 1965, and race 11, one time in 1964, all previously designated races before 1962 were not encountered in and after 1964. The rest of the races i. e., race 20, 21, 22 and 23 which were first designated in 1963 were encountered with steady frequencies during 1964-66.

There were fluctations in race appearances each year during the seven years period. The actual number of races detected was 13 races in 1960, 12 in 1961, 17 in 1962, 19 in 1963, 16 in 1964, 13 in 1965 and 14 in 1966.

In consideration of localities, 21 races were found in Ilan, 24 in Tungshu, 25 in Chiayi, 23 in Pintung, 25 in Taitung and 11 in Hualein. The distribution of the major races in the six areas were: Ilan, races 2, 14, 17 and 24; Tungshu, races 13 and 9; Chiayi, races 13, 17 and 2; Pintung, races 24, 17 and 2; Taitung, race 17 and Hualein, race 24. The patterns of race distribution in six localities where the uniform blast nurseries were located were quite similar. Among the 27 races so far characterized, 18 races were encountered over all the localities, except Hualein area, during the years of 1960-66.

Table 2. Physiologic races of *P. oryzae* characterized in Taiwan during 1960–1966.

Differential variety	Race designation																											Total no. of isolates	Total no. of races
	A	K		N	J				I								P					T							
	1	2	17	3	4	5	6	7	8	9	10	11	20	21	22	23	12	13	14	15	16	18	19	24	25	26	27		
Kung-shan-wu-snen-ken	R	S	S	R	S	S	S	S	R	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S		
Taichung 65	R	R	S	R	R	Sm	S	R	R	R	R	R	R	S	S	S	S	S	S	S	S	S	S	S	S	S	S		
Pai-kan-tao	R	R	R	R	R	Mr	S	R	R	Rs	R	S	R	R	R	R	S	S	Sm	Sr	S	S	R	R	S	S	R		
Taichung 171	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	R	S	R	R	S	S		
Chianung 242	R	R	R	R	R	R	S	R	S	R	R	R	R	R	S	S	S	S	S	S	S	R	S	S	R	S	S		
Kwang-fu 1	R	R	R	R	R	R	S	R	S	R	R	R	R	R	S	S	S	S	S	S	S	R	S	R	R	S	S		
Chianung-yu 280	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	R	R	R	R	S	S		
Taichung-line 33	R	R	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	S	S	S	S	R	R	R	R	R	S		
Kanto 51	R	R	R	R	S	M	S	S	R	R	R	R	R	R	R	S	S	R	Sr	R	S	R	S	R	R	R	R		
Norin 21	R	R	R	R	S	M	S	S	S	R	R	R	R	R	R	S	S	R	S	R	S	R	R	R	R	R	R		
Sensho	R	R	R	R	S	M	S	S	S	R	S	S	R	R	R	R	S	R	Sm	M	S	R	R	R	R	R	R		
Cutsugucul	R	R	R	R	Sm	S	S	S	R	R	R	S	R	S	S	S	Sm	S	Sr	R	S	R	R	R	R	R	S		
Natala	R	R	R	S	S	S	S	S	Sm	S	S	R	R	S	S	S	Sm	Sm	S	S	S	Sm	Sm	S	S	S	S		
Kao-chio-liu-chou	R	R	R	R	R	Sm	S	Sm	S	Sr	S	S	S	S	S	S	S	S	S	R	R	R	R	R	R	R	R		
Kaohsing-ta-li-chen-yu	R	R	R	R	R	M	S	Sm	S	S	S	S	S	S	S	S	S	S	Sr	R	R	R	R	R	R	R	R		
Taichung-ti-chio-wu-chien	R	R	R	R	Sm	R	Sm	Sm	S	S	S	S	S	S	S	S	S	S	M	R	R	S	R	R	R	R	R		
1960～1963	60	36	59	6	15	6	5	8	4	21	23	3	5	4	8	2	29	55	30	16	12	27	8	4	4			450	25
1964	24	16	20	5								1	3	5	3		2				1	1	9	36	3	18	4	151	16
1965	2	6	4	2						3			2	5	3	2	3							11		5	1	49	13
1966	9	11	8	13									8	10	6	2		1					1	17	1	2	4	93	14
Total	95	69	91	26	15	6	5	8	4	24	23	4	18	24	20	6	34	56	30	16	13	28	18	68	8	25	9	743	27

Table 3. Distribution and frequency of occurrence of physiologic races of *P. oryzae* characterized in Taiwan during 1960–1966.

Source	Year	Number of isolates																											Total no. of isolates	Total no. of races
		Group																												
		A	K		N	J				I								P					T							
		Race																												
		1	2	17	3	4	5	6	7	8	9	10	11	20	21	22	23	12	13	14	15	16	18	19	24	25	26	27		
Ilan	1960	1	1	1														1	1	2				1					8	7
	1	2	1	1		4						1							2	12			1						24	8
	2	10	2	1	1			2	2		2		1						1				3						25	10
	3	1	3	5		1									1	1							1		1				14	8
	4	4	4	3	2										1										9				23	6
	5		1	1							1				1										1		1		6	6
	6	1	4	2	4									1		2	1								3				18	8
	Total	19	16	14	7	5		2	2		3	1	1	1	3	3	1	1	4	14			5	1	14		1		118	21
Tungshu	1960	3	1	1		2				2	3	2						4	11		1								30	10
	1	1	1	1		2					9	5						3	6	5			7						40	10
	2					1		1	1		2	1						1	1				2						10	8
	3	7		1	1									1	2	1	1		3			1				2			20	10
	4	5	1	2											3	1		2				1	1	1	1		1		19	11
	5		1		2											1	1								3		1		9	6
	6	1		3	4									2					1						2	1			14	7
	Total	17	4	8	7	5		1	1	2	14	8		3	5	3	2	10	22	5	1	2	10	1	6	3	2		142	24

Chiayi	1960										2					2	3	1	1								9	5
	1	3	1	3												2	8	3			1						21	7
	2	4	6	3		2	1		1			1					2	6		1	6	5						38	12
	3	8	3	6	1				1		1			4	1	6	1	4	2		1		1	2	1	1			44	17
	4	8	4	4	1								1	3		1									7		12	1	42	10
	5	1													1	2		1							1			1	7	6
	6	2	2	1	1									1	2	1								1	1			1	13	10
	Total	26	16	17	3	2	1		2		1	3	1	8	4	10	1	11	19	4	3	6	7	3	10	1	12	3	174	25
Pintung	1960				1													2			3								6	3
	1	3	2	3							2	5						1	4	1	4			2					27	10
	2	6	5	8	1		3	1	2			4	2						1	2		1	2						38	13
	3	4	1	2																				2	1	1			11	6
	4	4	6	4	1																			2	12	1	1		31	8
	5		2	2							2			1	1			2							4		2		16	8
	6	2	3		1									3	4	1									5				19	7
	Total	19	19	19	4		3	1	2		4	9	2	4	5	1		5	5	3	7	1	2	6	22	2	3		148	23
Taitung	1960			8						2								2			1			1					14	5
	1	1	5	9							2	2						1	6	2			2						30	9
	2	3	2	5	1	3	2	1	1									4		2	4	4	2						34	13
	3	3	2	1																					1				7	4
	4	1		5	1										1	1								5	3		4	3	24	9
	5	1	1	1											1		1								1				6	6
	6	1		1	2									1	3	1	1								5			3	18	9
	Total	10	10	30	4	3	2	1	1	2	2	2		1	5	2	2	7	6	4	5	4	4	6	10		4	6	133	25
Hualein	1964	2	1	2																				1	4	2			12	6
	5		1											1	1										1		1		5	5
	6	2	2	1	1										1	1									1		2		11	8
	Total	4	4	3	1									1	2	1								1	6	2	3		28	11
Total		95	69	91	26	15	6	5	8	4	24	23	4	18	24	20	6	34	56	30	16	13	28	18	68	8	25	9	743	27

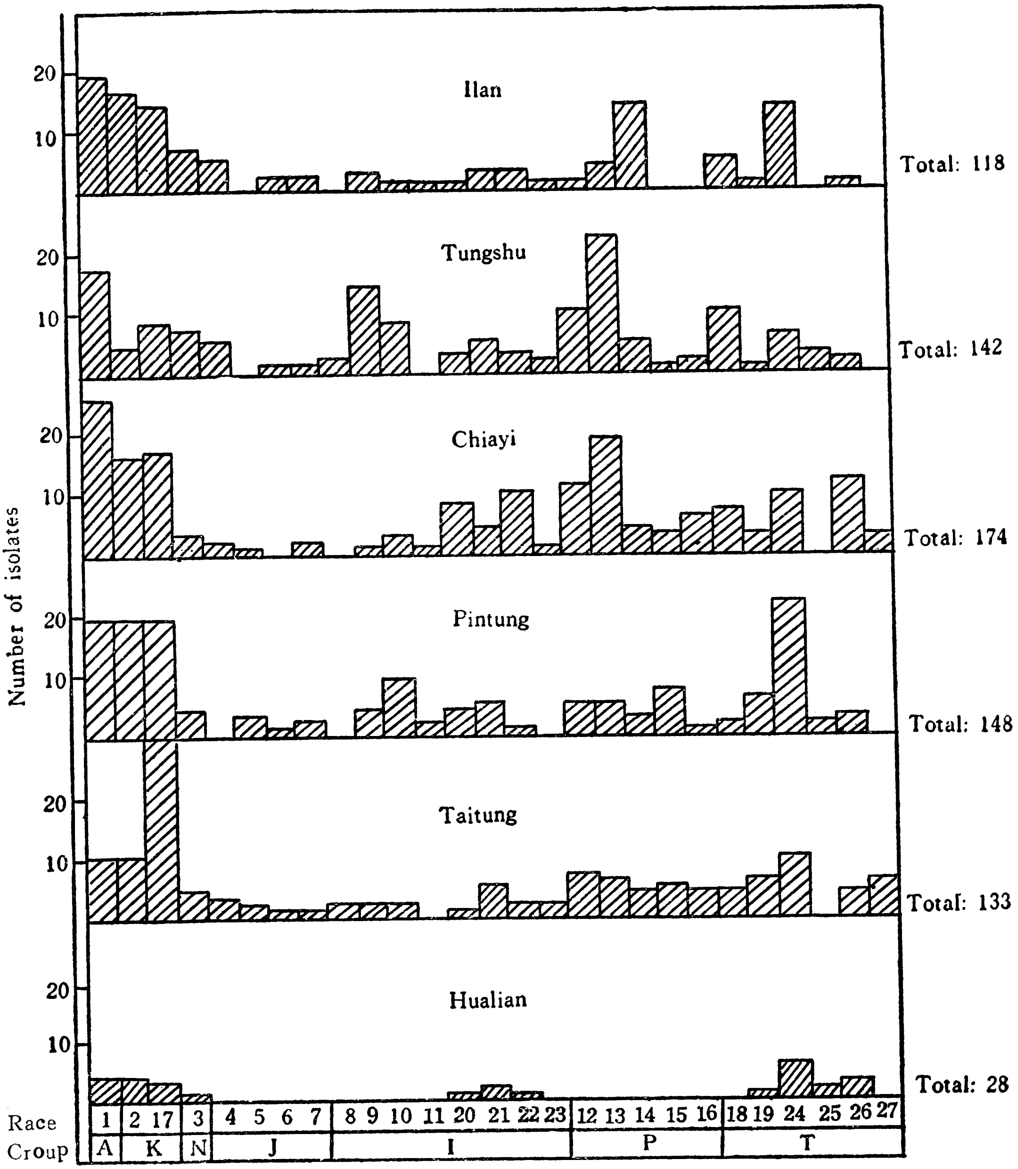
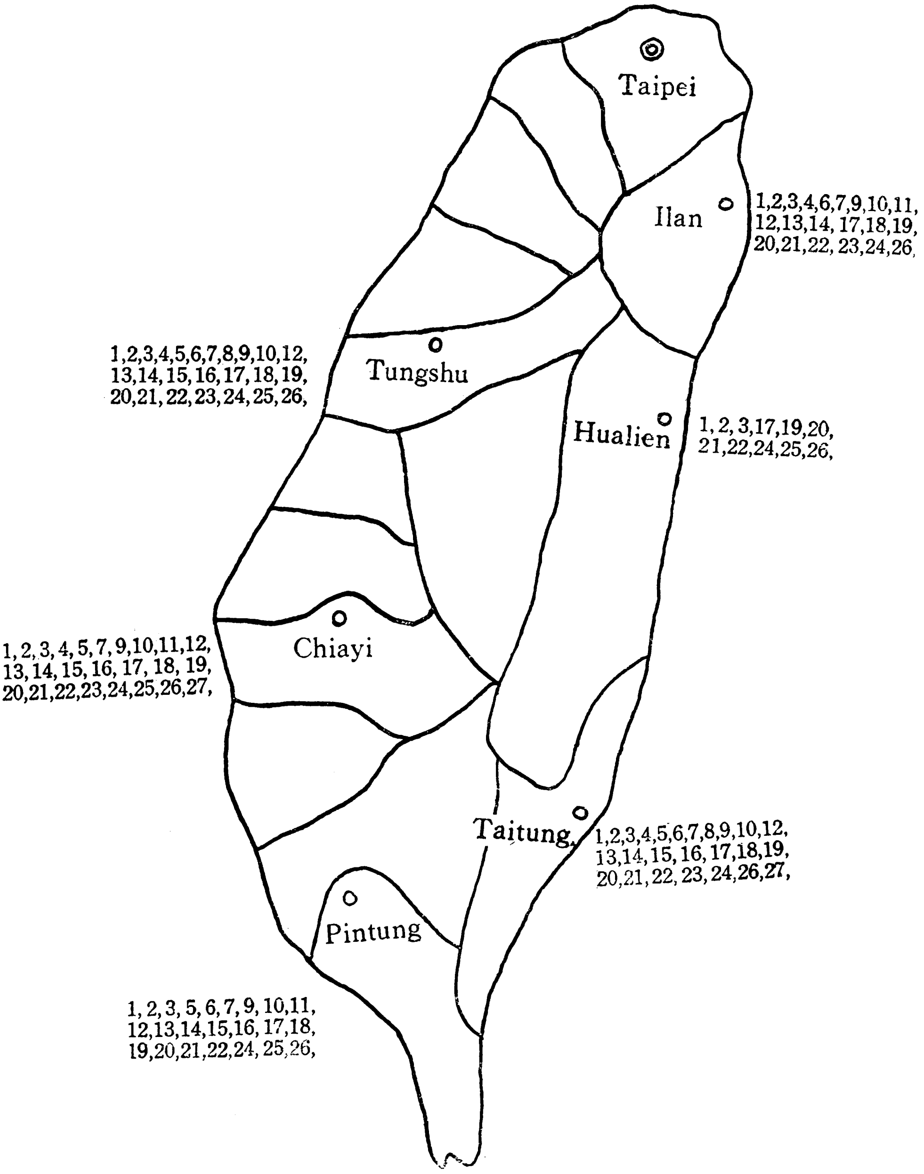


Fig 1. Distribution and frequency of occurrence of the 27 races of *P. oryzae* in Taiwan during 1960-66



Fig, 2. Geographic distribution of *Piricularia oryzae* races in Taiwan during 1960-1966

3. Reactions of the 16 Taiwan differential varieties to Japanese and U.S. races.

Eleven isolates representing eight Japanese races were tested for their pathogenicity on Taiwan differentials. The results are presented in Table 4.

Japanese race T-1 (Ken 53-33) could be included in P race group on Taiwan differentials. It infected all the 16 Taiwan differentials except CNY 280.

Japanese race T-2 did not show identical reactions for the two isolates (Ken 55-73 and Ken 62-88) when tested on the Taiwan differentials. Ken 55-73 gave a J race group reaction, while Ken 62-88 gave reaction similar to A race group, with susceptible lesions produced on KF-1 only.

Japanese race C-1 failed to give identical reactions for the two isolates (Ken 60-19 and ken 63-23) on the Taiwan differentials. Ken 60-19 gave the pathogenic pattern similar to Taiwan race 23. Ken 63-23 was less virulent than Ken 60-19.

Japanese race C-3 (Naga 87) gave a reaction similar to T race group on Taiwan differentials.

Japanese race N-1 (Hoku 373) gave the pathogenic pattern similar to Taiwan race 22 on Taiwan differentials. Taiwan race 22 gave the same reaction of N-1 on Japanese differentials as indicated in the later paragraph. It was believed that Japanese race N-1 was equavalent to Taiwan race 22.

Japanese race N-2 (Ai 62-22) gave the I race group reaction on Taiwan differentials.

Japanese race N-4 (Ina 168) behaved as Taiwan race 24 on Taiwan differentials. Yet Taiwan race 24 was not identical to Japanese N-4 on Japanese differentials.

Japanese race N-5 (Hoku 61-101) differed from any of the Taiwan races on Taiwan differentials. Naga 64-14, the other isolate in *Japanese race N*-5 gave the pathogenic reaction identical to Taiwan race 26 on Taiwan differentials. Yet Taiwan race 26 did not give the reaction pattern similar to the Japanese race N-5 on Japanese differentials.

Nine isolates representing six U.S. races were tested for their pathogenicity on the Taiwan differentials. The results are presented in Table 5.

U.S. Race 1, included two subraces, 1A and 1B. They were identical on the 16 differentials, if SM reactions were produced by race 1B on SS.

U.S. Race 3, produced SR and RS reactions respectively on KSWSK and TCTCWC. It gave resistant reaction on the rest of the varieties.

U.S. Race 4, caused RS reactions on KSWSK and KCLC, and R reaction on the rest of the varieties.

U.S. Race 5, included two subraces. Race 5A infected six varieties (KSWSK, NR 21, Nat., KCLC, KHTLC and TCTCWC), while race 5B infected five varieties (KSWSK, CNY 280, KCLC, KHTLC, and TCTCWC) of the Taiwan differentials.

U.S. Race 6, included two subraces, 6A and 6B. They were identical if RS reactions are produced on Cats by race 6B.

U.S. Race 7, caused S reactions on KSWSK, and RS reactions on three other varieties (KT 51, Nat., and KCLC).

Among the 16 Taiwan differntials, *indica type* varieties seemed more valuable as differentials than the *japonica type* varieties. Five *japonica type* varieties, i.e., TC 65 PKT, TC 171, CN 242, and KF 1 are not susceptible to any of the six U.S. races. Sucespitible reactions were produced on one *Japonica* type variety KSWSK by all the races.

Table 4. Reactions of Taiwan differential varieties to Japanese races of *P. oryzae*.

Variety	Japanese race										
	T-1	T-2	T-2	C-1	C-1	C-3	N-1	N-2	N-4	N-5	N-3
	Ken 53-33	Ken 55-73	Ken 62-88	Ken 60-19	Ken 63-23	Naga 87	Hoku 373	Ai 62-22	Ina 168	Hoku 61-101	Naga 61-14
Kung-shan-wu-shen-ken	S	S	R	S	S	S	S	S	S	S	S
Taichung 65	S	S	R	S	R	S	S	S	S	S	S
Pai-kan-tao	Sr	R	R	R	R	R	R	R	R	R	R
Taichung 171	Sr	R	R	S	R	R	S	R	R	Sr	S
Chianung 242	Sr	Sr	R	S	R	S	S	R	S	R	S
Kwang-fu 1	Sr	R	Sr	S	Sr	R	S	R	R	Sr	S
Chianung-yu 280	R	R	R	Sr	R	R	S	R	R	Sr	S
Taichung-line 33	Sr	R	R	S	R	R	S	R	R	R	R
Kanto 51	Sr	R	R	S	S	S	R	R	R	Sr	Sr
Norin 21	Sr	R	R	Mr	R	R	M	Sm	R	R	R
Sensho	Mr	R	R	R	R	R	R	Sr	R	R	R
Cutsugucul	S	R	R	S	Sr	R	S	R	R	R	R
Natala	S	R	R	S	Sr	S	S	S	S	R	S
Kao-chio-liu-chou	Mr	S	R	Sr	Sr	R	M	S	R	R	R
Kaohsing-ta-li-chen-yu	S	S	R	Sr	R	R	Ms	S	R	R	R
Taichung-ti-chio-wu-chien	S	S	R	Sr	R	R	Ms	S	R	R	R
Taiwan race equivalent				Ta.23			Ta.22?		Ta.24		Ta.26

Table 5. Reactions of Taiwan differential varieties to U.S. races of *P. oryzae*

Variety	U.S. race								
	1 A	1 B	3	4	5 A	5 B	6 A	6 B	7 A
Kung-shan-wu-shen-ken	S	S	SR	RS	S	S	S	S	S
Taichung 65	R	R	R	R	R	R	R	R	R
Pai-kan-tao	R	R	R	R	R	R	R	R	R
Taichung 171	R	R	R	R	R	R	R	R	R
Chianung 242	R	R	R	R	R	R	R	R	R
Kwang-fu 1	R	R	R	R	R	R	R	R	R
Chianung-yu 280	R	R	R	R	R	M	R	R	R
Taichung-line 33	R	R	R	R	S	R	R	R	R
Kanto 51	R	R	R	R	R	R	R	R	RS
Norin 21	R	R	R	R	R	RS	R	R	R
Sensho	SM	R	R	R	R	R	R	R	R
Cutsugucul	R	R	R	R	R	R	RS	R	R
Natala	R	R	R	R	S	R	S	S	RS
Kao-chio-liu-chou	S	S	R	RS	S	S	S	S	RS
Kaohsing-ta-li-chen-yu	S	S	R	R	S	S	S	S	R
Taichung-ti-chio-wu-chien	S	S	RS	R	S	S	S	S	R

4. Reactions of the U.S. and Japanese differentials to Taiwan races

Table 6 gives the reactions of the Japanese and U.S. differentials, respectively, to representative isolates of certain Taiwan races of *P. oryzae*. Most of these isolates were sent to the United States and Japan for tests at Beltsville, Maryland and Tokyo in exchange of cultures for the cooperative research.

It seemed that the U.S. differentials did not provide a good differentiation for the Taiwan races. Races 9, 22 and 24 were indistinguishable on the U.S. differentials. The same reactions were also obtained for races 13 and 16, and for races 14, 17 and 19. But, rather satisfactory separation of these races was obtained with Japanese differentials.

Taiwan race 1 (3C-58G) lost their pathogenicity during culturing. None of the Taiwan, U.S. or Japanese differentials were infected by this isolate.

Taiwan race 2 (2 Γ-74S) gave susceptible reaction only on KSWSK of the 16 Taiwan differentials. It infected CI 8970-P and Aichi-asahi of the U.S. and Japanese differentials, respectively.

Taiwan race 3 (2K-27S) infecting only Natala of the Taiwan differentials induced susceptible reactions on Rexoro and Taichung 65 of the U.S. differentials. However, Taich-

ung 65 when tested along with other Taiwan varieties showed resistant reaction to this isolate. Usen and Ishikari-shiroke in the Japanese differentials were found susceptible to this race.

Taiwan race 5 (2K-24S) belonging to J race group on Taiwan differentials was pathogenic to five varieties of the U.S. differentials, namely, Rexoro, Lacrose, Caloro, CI 8970-P and Taichung 65. It showed the same pathogenic pattern as U.S. race 6. However, U.S. race 6 did not give the Taiwan race 5 pattern on the Taiwan differentials. On the Japanese differentials, it was pathogenic to Usen, Ishikari-shiroke, Homare-nishiki, Aichi-asahi, Norin 20 and Pi No. 1.

Taiwan race 9 (3C-109M) seemed to be different from any of U.S. and Japanese races. It was highly pathogenic to the Japanese differentials. Of the U.S. differentials, only Caloro, CI 8970-P and Taichung 65 were found susceptible to this isolate.

Taiwan race 12 (2S-74S) infected all of the Taiwan differentials. On the U.S. differentials, it induced the pathogenic pattern similar to U.S. race 21. However, U.S. 21 did not show Taiwan race 12 pattern on the Taiwan differentials. It gave the same pathogenic pattern as Japanese race N-6, on the Japanese differentials.

Taiwan race 13 (2C-2124S) showed the highest virulence to both the U.S. and Japanese differentials. Te-tep, Tudukan, Chokoto and Yakeiko were the only varieties among the Japanese differentials which were resistant to this race. It differed from any of the Japanese races on the Japanese differentials. When tested on the U.S. differentials, Taiwan race 13 gave the reaction pattern identical to U.S. 17, yet U.S. rece 17 did not show the Taiwan race 13 pattern on the Taiwan differentials.

Taiwan race 14 (1I-29S) representing one of the most virulent races on the Taiwan differentials showed only moderate pathogenicity on the Japanese differentials and weak pathogenicity on the U.S. differentials. This isolate induced the pathogenic pattern similar to U.S. race 4 on the U.S. differentials. On the Japanese differentials, it showed the pathogenic pattern similar to Japanese N-2, if susceptible reaction was not obtained on Pi No. 1.

Taiwan race 16 (2C-86S) gave the same pathogenic pattern as U.S. race 17 on the U.S. differentials. It seemed to be different from any of the Japanese races.

Taiwan race 17 (2K-82S) gave the same pattern of Japanese N-2 on Japanese differentials. It behaved like U.S. race 2 on the U.S. differentials.

Taiwan race 19 (4K-18S) showed weak pathogenicity to both the U.S. and Japanese differentials. It gave susceptible reactions on Caloro and Taichung 65 in the U.S. differentials. Of the Japanese differentials, only Norin 20 and Norin 22 were infected.

Taiwan race 22 (4T-28S) showed rather strong pathogenicity to the Japanese differentials, but weak pathogenicity to the U.S. differentials. The pathogenic pattern of this race on the Japanese differentials was identical to the Japanese race N-1.

Taiwan race 24 (4C-25S) produced the same pathogenic pattern as Taiwan races 9 and 22 on the U.S. differentials.

Taiwan race 26 (4T-27Sb) seemed to be different form any of U.S. and Japanese races. It gave the pathogenic patterns similar to Taiwan races 9, 22 and 24, on the U.S. differentials.

Table 6. Reactions of U.S. and Japanese differential varieties to Taiwan races of *P. oryzae*.

Variety	Taiwau Race													
	1	2	3	5	9	12	13	14	16	17	19	22	24	26
	3C-58G	2T-74S	2K-27S	2K-24S	3C-102M	2S-74S	2C-2124S	1I-29S	2C-86S	2K-82S	4K-18S	4T-28S	4C-25S	4T-27Sb
U.S. differentials														
Zenith	R	R	R	R	R	R	S	R	S	R	R	R	R	R
Rexoro	R	R	Sr	S	R	S	S	R	S	R	R	R	R	R
Lacrosse	R	R	R	S	R	R	S	R	S	Rs	R	R	R	R
Caloro	R	R	R	S	S	S	S	S	S	S	S	S	S	S
CI 8970-P	R	S	R	S	S	S	S	R	S	R	R	S	S	S
CI 8970-S														
CI 5309	R	R	R	R	R	R	R	R	R	R	R	R	R	R
PI 180061	R	R	R	R	R	R	R	R	R	R	R	R	R	M
PI 201902	R	R	R	R	R	R	R	R	R	R	R	R	R	R
PI 231128	R	R	R	R	R.	R	R	R	R	R	R	R	R	R
PI 231129	R	R	R	R	R	R	R	R	R	R	R	R	R	Sr
Taichung 65	R	R	Rs	S	S	S	S	S	S	S	Sr	Sr	S	M
Japanese differentials														
Te-tep	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Tadukan	R	R	R	R	R	S	R	R	R	R	R	R	R	R
Usen	R	R	S	S	S	R	S	Rs	S	R	R	R	R	R
Chokoto	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Yakeiko	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Kanto No.51	R	R	R	R	R	R	S	R	R	R	R	R	R	R
Ishikari Shiroke	R	R	S	S	S	S	S	R	S	R	R	S	S	S
Homare-nishiki	R	R	R	S	R	R	S	Rs	Rs	S	R	S	R	R
Ginga	R	R	R	R	S	R	S	S	Rs	S	R	S	S	S
Norin No.22	R	R	R	R	S	S	S	S	Rs	S	S	S	S	S
Aichi asahi	R	S	R	S	S	S	S	S	S	S	R	S	R	S
Norin No.20	R	R	R	S	S	S	S	S	S	S	S	S	R	S
Pi. No. 1	R	R	R	S	M	R	S	S	S	R	R	M	R	S
U.S. race equivalent	U.S. 10?			U.S. 6?		U.S. 21?	U.S. 17?	U.S. 4?	U.S. 17?	U.S. 2?				
Japanese race equivalent						N.6				N.2		N.1		

5. Reactions of the 12 tentative internat ional differentials supplied by J. G. Atkins, U.S.D.A. to Taiwan races of P. oryzae.

All varieties in groups 1 (Tadukan), 2 (Zenith and NP. 125), 3 (Usen), and 4 (C. I. 5309, Kanto 51, and Dular) gave resistant reactions to the eight races tested, with one exception that RS reaction was induced by race 16 on Usen, the only variety in group 3. On C.I. 8970-S, the variety in group 5, resistant reaction was caused by race 1, while susceptible reaction by races 16, 17, 22, and 26. SR or RS reactions were produced by races 3, 5, and 11 on this variety. Three varieties (Norin No. 20, Caloro, and Aichi asahi) in group 6 reacted resistantly to races 1 and 11 but susceptiblely to rece 22. Inconsistent reactions were shown on this variety group by the rest of the races. (Table 7)

Table 7. Reactions of the tentative international differentials supplied by J. G. Atkins. U.S.D.A. to Taiwan races of *P. oryzae*

Group no. and variety	Taiwan race							
	1	3	5	11	16	17	22	26
	3C-58G	2K-27S	2K-24S	2K-20S	2C-86S	2K-82S	4T-28S	4T-27Sa
Group 1								
Tadukan	R	R	R	R	R	R	R	R
Group 2								
Zenith	R	R	R	R	R	R	R	R
NP. 125	R	R	R	R	R	R	R	R
Raminad str.3								
Group 3								
Usen	R	R	R	R	R S	R	R	R
Group 4								
C.I. 5309	R	R	R	R	R	R	R	R
Kanto No. 51	R	R	R	R	R	R	R	R
Dular	R	R	R	R	R	R	R	R
Group 5								
C.I. 8970-S	R	S R	S R	R S	S	S	S	S
Group 6								
Norin No. 20	R	R	R	R	R	R S	S	S
Caloro	R	S R	S R	R	S	S R	S	S
Aichi asahi	R	R	R S	R	S	R	S	R

6. Reactions of the 24 tentative international differentials suupplied by IRRI to Taiwan races of P. oryzae.

Ten isolates representing ten races were tested for their pathogenicity to the 24 tentative international differentials. No pathogenic reactions were observed in all races on varieties of groups 1 (Te-tep and Tadukan), 2 (Zenith, Wag-wag, Raminad str. 3 and NP-125) and 4 (Chokoto, Yakeiko, G.I. 5309, Kanto 51 and Dular). Races 3, 13, 16, and 22 caused S-R reactions on varieties of group 3, while resistant reactions were given by races 1, 5, 11, 14, 17, and 26 on varieties of this group (Usen, Pi. No. 1, and Lacrosse). Varieties of group 5 (Ishikari-Shiroke, C. I. 8970-P, C. I. 8970-S, and Rexoro) gave resistant reaction to races 1, 5, 11, and 13. Only one or two varieties of this group gave RS or SR reaction to races 3, 17, 22, and 26. Race 16 is pathogenic to three varieties of this group. All varieties in Group 6 (Homare nishiki, Ginga, Taichung 65, Norin No. 22, Caloro, and Aichi asahi) reacted resistantly to race 1, but susceptiblely to race 22. Races 11, 16, 17, and 26 infected two varieties (Taichung 65 and Caloro) of the group, while races 3, 5, and 13 infected three varieties. (Table 8).

7. Reactions of 40 rice varieties supplied by FAO to Taiwan race of P. oryzae.

The 40 rice varieties from FAO were tested for their reactions to nine Taiwan races of *P. oryzae*. The results are presented in Table 9. All nine races caused resistant reaction on varieties of group 1, but susceptible reactions on varieties of group 6. Moderately resistant reactions were produced by races 12, 13, 17 and 22 on only one or two varieties of group 2. Varieties of group 3 seemed highly resistant to the races tested. Races 14, 17 and 18 all produced resistant reactions on this variety group; races 5, 13, and 22 each induced susceptible reaction only on one variety; races 9 and 12 induced susceptible reactions on two varieties among 8 varieties. Susceptible reactions were produced by race 3 on three varieties in the same group. Varieties of group 4 gave resistant reactions to races 3 and 13. Only one variety of this group gave susceptible reactions to races 5 or 18. Races 9 and 14 were pathogenic to two varieties of this group. Racec 12, 17 and 22 caused S-M reaction on four varieties of the group. Resistant reactions were produced by race 14 on all varieties of group 5. Race 17 and 18 caused MR and SR reactions respectively on Woo-Gen and T 141. The rest of the races are highly pathogenic to the varieties of this group.

8. Reactions of commercial rice varieties to Taiwan races of P. oryzae.

Twenty commercial rice varieties including two native Taiwan varieties i.e., Ai-Chueh-Chien and Taichung-native 1, and 18 *japonica* type varieties were tested for their reactions to eight Taiwan races of *P. oryzae*. Results are given in Table 10. Races 12, 13, and 16 are of the most pathogenic *ones* among the races tested. Of 20 varieties tested, only Taichung 186 Taichung-yu 184 were resistant to these races, while Taichung-native 1 resistant to races 12 and 13, but susceptible to race 16. Races 17, 24, and 26, the races of second pathogenic caused resistant reactions on the varieties of group 1 (Taichung 186 and Taichung-yu 184), but susceptible reactions on all varieties of group 2 (Taichung 65, Kaohsiung 24, Taipei 306 and Taipei 308) and group 3 (Tainan 1, Chianan 8, Kaohsinng 10, Kaohsiung 27, Kaohsiung

64, and Hsinchu 56). These three races induced S reaction on one or two varieties in group 4, and S-M-R reactions on some varieties of groups 5. Race 5 caused susceptible reactions on all varieties in group 5 (Taichung 178, Kaohsiung 122, Ai-Chueh-Chian, Taichung-native 1), and on two varieties in group 4 (Chianung 242 and Taipei 177). All varieties in groups 1 and 3 and two varieties in group 4 gave resistant reactions to the race. Race 1, the weakest in pathogenicity, caused resistant reactions on most of the verieties, a few varieties (Kaohsiung 24, Chianan 8, Kaohsiung 10, 64 and Hsinchu 56), however, showed RS reactions to the race.

Table 8. Reactions of the 24 tentative international differentials supplied by IRRI to Taiwan races of *P. oryzae*.

Group no. and variety	Taiwan race									
	1	3	5	11	13	14	16	17	22	26
	3C-58G	2K-27S	2K-24S	2K-20S	2C-2124S	1I-29S	2C-86S	2K-82S	4T-28S	4T-27Sa
Group 1										
Te-tep	R	R	R	R	R	R	R	R	R	R
Tadukan	R	R	R	R	R	R	R	R	R	R
Group 2										
Zenith	R	R	R	R	R	R	R	R	R	R
Wag-wag	R	R	R	R	R	R	R	R	R	R
Raminad str. 3	R	R	R	R	R	R	R	R	R	R
NP-125	R	R	R	R	R	R	R	R	R	R
Group 3										
Usen	R	R S	R	R	R S	R	S	R	S R	R
Pi. No. 1	R	R S	R	R	R S	R	S R	R	R	R
Lacrosse	R	R	R	R	R S	R	S	R	S R	R
Group 4										
Chokoto	R	R	R	R	R	R	R	R	R	R
Yakeiko	R	R	R	R	R	R	R	R	R	R
C. I. 5309	R	R	R	R	R	R	R	R	R	R
Kanto 51	R	R	R	R	R	R	R	R	R	R
Dular	R	R	R	R	R	R	R	R	R	R
Group 5										
Ishikari-shiroke	R	R	R	R	R	R	R	R	R	R
C. I. 9870-P	R	R	R	R	R	R S	S	R S	S R	R
C. I. 8970-G	R	R S	R	R	R	R S	S	R	S	R S
Rexoro	R	R	R	R	R	R	R	R	R	R

Group 6										
Homare-nishiki	R	R	RS	R	R	RS	R	R	S	R
Ginga	R	R	RS	R	R	RS	R	R	SR	R
Taichung 63	R	RS	SR	RS	S	S	S	S	S	S
Norin 22	R	R	R	R	R	S	R	R	S	R
Caloro	R	SR	SR	S	S	S	S	S	S	S
Aichi-asahi	R	SR	R	R	S	S	R	R	S	R

Table 9. Reactions of the 40 rice varieties supplied by FAO to Taiwan races of *P. oryzae*.

Group no. and variety	Taiwan race								
	3	5	9	12	13	14	17	18	22
	2K-27S	2K-24S	3C-102M	2S-74S	2C-2124S	1I-29S	2K-82S	2S-17S	4T-28S
Group 1									
PI 180061	R	R	R	R	R	R	R	R	R
Kanto 51	R	R	R	R	R	R	R	R	R
M-302	R	R	R	R	R	R	R	R	R
H-4	R	R	R	R	R	R	R	R	R
H-5	R	R	R	R	R	R	R	R	R
Murungakayan 302	R	R	R	R	R	R	R	R	R
Slo 15 (from 61A)	R	R	R	R	R	R	R	R	R
BR 7	R	R	R	R	R	R	R	R	R
Ninidhan	R	R	R	R	R	R	R	R	R
221/BCIV/I/178/3	R	R	R	R	R	R	R	R	R
221/BCIV/I/178/11	R	R	R	R	R	R	R	R	R
Hakkodo	R	R	R	R	R	R	R	R	R
G. B. 121	R	R	R	R	R	R	R	R	R
H-105	R	R	R	R	R	R	R	R	R
Samo Ran	R		R	R	R	R	R	R	R
Group 2									
Samo Trang	R	R	R	R	R	R	RM	R	R
FE 165	R	R	R	R	M	R	R	R	R
Tadukan	R	R	R	RM	M	R	R	R	R
Hybrid I	R	R	R	MR	R	R	R	R	M

Group 3									
Dud Kuning	R	R	S R		R	R	R	R	
Yakeiko	R	R	S R	R	R	R	R	R	R
Bengawan	S	R	R	R	R	R	R	R	R
D 25-4	S	R	R	R	R	R	R	R	R
Nepali Tulasi (Sel)	R	R	R	S	R	R	R	R	R
C 46-15	R	R	R	R	S	R	R	R	R
Hybrid II	R	R	R	S R	R	R	R	R	S
Fa-Yiu Tsai	S	S	R	R	R	R	R	R	R
Group 4									
A. C. 2250	R	R	R	RM	R	R	S R	R	S
Ginga	R	R	R	M	R	S	R	R	S
Nhta-6	R	R	S	S	R	R	RM	R	R
C 33-18	R	R	R	R	R	R	S R	S R	S R
T.K.M. 6	R	S R	S	R	R	R	R	R	S R
G.S. 336	R	R	R	S	R	R	S R	R	R
Group 5									
Tjere Mas	M	S R	M	R	R	R	R	R	RM
Woo-Gen	R	R	S R	S	R	R	MR	R	S
Patnai 23	S	S R	R	R	S	R	R	R	M
T 141	S	S	S R	R	S	R	R	S R	RM
M.T.U. 3	S	S	S	S	S	R	R	R	R
Group 6									
Usen	S	S	S R	S	S	S	S M	S	S
U.S.A. Caloro	S	S M	S	S	S	S	S R	S	S

Table 10. Reactions of commercial rice varieties to Taiwan races of *P. oryzae*.

Group no. and variety	Taiwan race							
	1	5	12	13	16	17	24	26
	3C-58G	2K-24S	2S-74S	2C-2124S	2C-86S	2K-82S	4C-25S	4T-27Sa
Group 1								
Taichung 186	R	R	R	R	R	R	R	R
Taichung-yu 184	R	R	R	R	R	R	R	R

Group 2								
Taichung 65	R	R	S	S	S	S	S	S
Kaohsiung 24	RS (17:3)[a]	S	S	S	S	S	S	S
Taipei 306	R	S	S	S	S	S	S	S
Taipei 398	R	S	S	S	S	S	S	S
Group 3								
Tainan 1	R	R	S	S	S	S	S	S
Chianan 8	R S (18:2)	R	S	S	S	S	S	S
Kaohsiung 10	R S (18:2)	R	S	S	S	S	S	S
Kaohsiung 27	R	R	S	S	S	S	S	S
Kaohsiung 64	R S (17:3)	R	S	S	S	S	S	S
Hsinchu 56	R S (16:4)	R	S	S	S	S	S	S
Group 4								
Chianung 242	R	S	S	S	S	R	S	S
Taipei 177	R	S	S	S	S	S	R	S
Tainan 3	R	R	S	S	S	S	R	R
Hsinchu 61	R	R	S	S	S	R	R	R
Group 5								
Taichung 178	R	S	S	S	S	RM (16:4)	S	R S (15:4)
Kaohsiung 122	R	S	S R (13:7)	S	S	MR (12:8)	S	RM (17:3)
Ai-chueh-chien	R	S	R S (13:7)	S	S	R S (15:5)	R	R
Taichung-native 1	R	R S (13:7)	R	R	S	R	RM (10:7)	R

a. The number of leaves for different reactions.

9. **Physiologic races of P. oryzae characterized in one field block**

Thirty five isolates of *P. oryzae* were isolated from the disease specimens collected randomly from a blast nursery consisting of one rice variety Taichung 65. Cultures of *P. oryzae* were single-spore isolated and tested for their pathogenicity on the 16 differential varieties in the greenhouse.

The results presented in Table 11 indicate that there are several races of *P. oryzae* existing in one field block. The difference in frequency of occurrence was shown by the races. Fourteen isolates were identified as race 26, seven isolates as race 24, three isolates as race 21 and the other three isolates as race 1. Only one isolate was identified as race 20. There were 5 isolates showing the pathogenicity which did not belong to the existing race patterns.

These races can be further placed into four race groups. Race 1 belonged to A race group, race 17 to K race group, race 20 and 21 to I race group, and race 24 and 26 to T

race group. The rest of isolates comprising 14.3% of the total isolates did not belong to any race group. It was noticed from this experiment that the most prevalent race belonged to the T race group. No isolates were identified as races belonging to J or P race group, although the disease specimens were collected from *japonica* type rice variety.

Table 11. Physiologic races of *P. oryzae* Cav. characterized in one field block

Group	A	K	I		T		Isolates not included in the existing race
Race	1	17	20	21	24	26	
Number of isolate	3	2	1	3	7	14	5
Percentage of isolate in race group	8.5	5.8	11.4		60.0		14.3

10. Race characterization of P. oryzae Cav. by using the eight international differentials.

The eight international differential varieties were tested for their reactions to the isolates of *P. oryzae* which had been characterized with the U. S., Japanese or Taiwan set of differential varieties, and to some newly collected isolates of *P. oryzae* in Taiwan. The results are given in Table 12.

when the isolates of Japanese races were characterized with the international set of differentials, five former Japanese races T-1, T-2, C-1, C-3, N-1, would fall into IC-5, ID-10, IE-1, IF-2, IG-1 respectively. Former Japanese races N-2, N-4. and N-5 would be included in IH-1. Former U.S. races 1, 7, 3, 5B would fall into IB-5, IF-1, IG-1 and IG-2 respectively. Former U.S. raes 5A and 6B, and races 2 and 4 would be designated as ID-8 and IH-1 respectively. Former Taiwan races 3, 4, and 5 could be designated as ID-8, race 16 as IE-1, races 9, 12, 13, 20, 22, 24, 26, and 27 as IG-1, race 21 as IG-2, and races 2, 17, and 19 as IH-1. However, in the U.S.-Japanese Cooperative Study, former Japanese races T-1, and N-5 were designated as IC-1 and IG-1 respectively, and former U. S. races 5A, 6B and 7A were designated as ID-9, ID-8, and IB-2 or IB-4, respectively (4).

When, newly collected isolates in 1966 were tested on the international set of differentials, almost three fourths of the isolates were characterized into IG and IH race groups. Since the key varieties of these group, i.e., C.I. 8970 (S) and Caloro are susceptible to most races (4), the Taiwan isolates designated as IG or IH groups could be considered as the races of rather weak pathogenicity.

It was also noticed that the strains of *P. oryzae* designated by using the international differentials could be split into more different race groups when the Taiwan differential varieties were used for race characterization. For instance, isolates designated as IG-1 could be split into eight Taiwn races included in P, I, and T race groups.

Table 12. Pathogenic races and isolates characterized by the 8 international differential varieties

International race group	International race	Reaction per differential variety								Prior race			newly collected Taiwan isolate
		Raminad Str. 3	Zenith	NP-125	Usen	Dular	Kanto 51	CI. 8970 (S)	Caloro	US	Japan	Taiwan	
I B	5	R	S	R	R	S	R	S	R	1A			
I C	3	R	R	S	R	S	S	S	S				1
	5	R	R	S	R	R	S	S	S		T-1 (IC-1)		
I D	8	R	R	R	S	R	R	S	S	5A (ID-9)[a] 6B (ID-8)		3,4,5	2
	10	R	R	R	S	R	R	R	S		T-2		1
	11	R	R	R	S	R	R	R	R				
I E	1	R	R	R	R	S	S	S	S		C-1	16	3
	2	R	R	R	R	S	S	R	S				1
	3	R	R	R	R	S	R	S	S				3
	4	R	R	R	R	S	R	R	S				1
I F	1	R	R	R	R	R	S	S	S	7A(IB-2, IB-4)			4
	2	R	R	R	R	R	S	S	S		C-3		
I G	1	R	R	R	R	R	R	S	S	3	N-1	9,12,13,20, 22,24,26,27	24
	2	R	R	R	R	R	R	S	R	5B		21	15
I H	1	R	R	R	R	R	R	R	S	2,4	N-2 N-4 N-5 (IG-1)	2,17,19	14

a. The race designated by the U.S.-Japanese Cooperative Study.

Discussion and Conclusion

The prevailing races of the blast fungus varied from year to year. Among the 27 races so far characterized, races 17, 2 and 24 were the most predominant ones. Race 13, the most predominant one of 1960-1961, became less prevalent later in 1962 and 1963, and was not encountered during 1964-1965. Only one isolate collected from Tungshu was characterized as race 13 in 1966. The same trend was also observed with race 12. Races in J and P groups with a few exceptions, were not encountered in and after 1964. On the other hand, race 24 which was first designated with four isolates in 1963 was identified as many as 36 times in 1964. It has become the most predominant race since then.

Most races designated in and after 1964 belonged to race groups of K, N, I and T. Only a few isolates were designated as races in P race group. In I race group. only four out of 53 isolates characterized during 1964-66 fell into the existing race patterns designated before 1962, i. e., races 9 and 11. The rest of isolates fell into the race pattern of newly designated, i. e., races 20, 21, 22 and 23 which were encountered with steady frequencies since 1963. No isolates were designated as races in J race group since 1964.

The patterns of race distribution in six localities where the uniform blast nurseries were located were quite similar. Among 27 races so far characterized, 18 races were encountered over all the localities, except Hualein area, during the years of 1960-66, The rest of the races were encountered in some localities with minor prevalence. Apparently, there was no local peculiarity in race distribution within the island of Taiwan.

The relative prevalence of a given race could be expected to change with shifts in acreage of susceptible rice varieties (3). In the uniform blast nurseries, the varieties of rice planted were changed from year to year. Susceptible varieties were screened out and not planted in the following years. More resistant rice varieties were provided for commercial use, especially blast resistant varieties of Ponlai rice which were distributed for increasing acreage of planting this type of rice (22). Most of Ponlai rice varieties inherited the blast resistant quality of native rice. It is assumed that increasing acreage of planting Ponli rice varieties brings on the shifts of races of the blast fungus in Taiwan.

It was evident that no isolates collected in and after 1964 showed infectious ability to the varieties of Japanese origin, namely Kanto 51, Noring 21 and Sensho in Taiwan differential varieties, except a few isolates in race 12. However, Kanto 51 received from IRRI as one of the eight international differentials was susceptible to some newly collected isolates in 1966, which were designated as the races other than race 12. This phenomenon might be due to the different origins of seeds of Kanto 51 in the international differentials and those in Taiwan differentials. The susceptiblity of this rice variety to the blast fungus might change during the successive cultivation in the different localities. In order to compare research information on an international basis, the seeds for differential varieties should be distributed to the investigators by a certain organization every year.

Evaluations of the U.S. and Japanese differentials were made with several representative

isolates in Taiwan races. The U.S. differential varieties did not provide a satisfactory differentiation for the Taiwan races. They differentiated some race pairs that show a general similarity in host reaction. However, they failed to distinguish some other races; several Taiwan races showed identical pathogenic pattern on the U.S. differentials. The Japanese differential varieties provided unequivocal separation of Taiwan races. Fourteen isolates representing 14 Taiwan races were distinguished from one another on Japanese differentials.

The Taiwan differentials provided a satisfactory differentiation for Japanese races. The reactions obtained with certain Japanese isolates on Taiwan differentials agreed with those recorded in tests made in Tokyo (27). It was evident that isolates of the same race charact erized by Japanese workers could be further differentiated by the Taiwan differential varieties. Among the 16 Taiwan differentials, *indica* type varieties seemed more valuable as differentials for U.S. races, while *japonica* type rice varieties mostly showed resistant reactions

According to Kozaka, *et al.* (28), the major races in Taiwan may consist of Japanese N-group races and of the Philippines races. He indicated that Taiwan race 2 and 17 were identical to Japanese N-4 on Japanese differentials. Having tested the *P. oryzae* isolates from Taiwan on Japanese and U. S. differentials, Goto and Kozaka reported the presence of Japanese races N-3, N-4 and N-5, and U.S. races 4 and 18 in Taiwan (2). The evidences were also indicated by Latterell *et al.* (18). They reported that U.S. races 18 and 21 isolated from specimens received from Taiwan appeared to have the same affinities as Japanese N-5 and N-1. In tests conducted in Taiwan, Taiwan races 12, 7 and 22 gave pathogenic pattern identical to Japanese N-6, N-2 and N-1, respectively on Japanese differentials, and Japanese race C-1, N-1, N-4 and N-5 showed the pathogenic patterns identical to Taiwan races 23, 22, 24 and 26 respectively on Taiwan differentials. Taiwan races 5, 12, 14, 13 or 16 and 17 showed pathogenic pattern identical or similar to the U.S. races 6, 21, 4, 17 and 2, respectively on the U.S. differentials, and the U.S. races 3 and 4 showed the reaction similar to race pattern of Taiwan race 2 on Taiwan differentials. Among U.S. races, races 2, 3, 4 and 21 are equivalent to Japanese N race group in the international differentials (4). Further evidences were obtained when the Taiwan races were tested on the international differentials. Most Taiwan races could be designated as races in IG and IH groups in which all prior Japanese N races were assigned. It is not surprising that the main races in Japan are present in Taiwan, since *japonica* type rice varieties are widely cultivated here. These facts might suggest that Taiwan and Japan share the same main races, prior N-race group. However, the blast disease in Taiwan has seldom caused serious damage as compared with that happened in Japan. The phenomenon that rice in 1st crop is more susceptible to the blast disease than in 2nd crop, might be due to the environmental factors influencing the growth of rice, which in turn show the different susceptiblity to the blast fungus. Lower temperatures during the 1st crop, which prolong the growth period of rice make it susceptible to the blast fungus. The susceptible period of rice in Taiwan is shorter than in Japan, and rice varieties, especially most of Ponlai rice of present cultivation inherited

the blast resistant quality from the native rice. Therefore less damage by the rice blast disease in Taiwan could be expected.

On the whole, more complex race patterns were obtained with Taiwan differentials than with the U.S. and Japanese differentials. The great complexity of rice varietal composition in Taiwan and the number of differentials employed for race characterization are the factors responsible for the complex race patterns (7). In individual countries where the eight international differentials are not sufficient for established rice-breeding program, the use of local subsidiary varieties was suggested by the U.S.-Japanese cooperatiue study (4). Since the present 16 Taiwan differentials have given a complex race pattern, and since most of the isolates collected in Taiwan were characterized into IG and IH groups, it is of necessity to select a set of superior differentials as a subsidiary varieties in Taiwan. Among the 16 Taiwan differentials, varieties which showed definite resistant or susceptible reaction to most of the existing blast races could be selected as candidate for subsidiary differential varieties. Varieties of Kanto 51, Pai-kan-tao, Chianung 242, Kao-chio-liu-chou, Taichung 65, and Kung-shan-wu-shen-ken in Taiwan differentials seemed to show a good differentiating ability. If these varieties are utilized as a set of differentials, isolates so far collected in Taiwan could be characterized into 17 races instead of the present 27 races.

As previously stated, most isolates of Taiwan races and newly collected isolates in 1966 were assigned as IG and IH race groups when the international differential varieties were used. The rest of the isolates with a minor instances were assigned as IC, ID, IE and IF race groups. No isolates tested were assigned as races in IA or IB groups. Atkins *et al.* (4) indicated that IA group of races occurs in Asiatic countries including Taiwan. However, according to the results of our tests, no isolates have been designated as races in the IA group. Since isolates which showed the IA pattern was obtained by the U.S. workers from specimen provided by the Taiwanese workers, the occurrence of this race in Taiwan is probable.

Summary

1) Nineteen races of *Piricularia oryzae* Cav., were characterized from 293 isolates of the blast fungus obtained during 1964-1966. Among them, 17 races representing 259 isolates-showed the pathogenic patterns which had already been detected. The two newly chara cterized races (races 26 and 27) showed T race group patterns. Race 24 was the most prevalent race in 1964, being encountered 64 times. Another prevalent races of the period were races 17, 2, 3, 26, and 21.

2) Nine isolates representing six U.S. races and eleven isolates representing eight Japanese races were tested for their pathogenicity on the Taiwan differentials. Among the 16 Taiwan differentials, *indica* type varieties seemed more valuable as the differentials for the U.S. races than the *japonica* type varieties. Isolates of the same Japanese races did not give identical reactions on the Taiwan differentials. The pathogenic patterns on the Taiwan differentials, induced by Japanese race C-1 (Ken 60-19), N-1 (Hoku 373), N-4 (Ina-168) and N-5 (Naga 61-14) were identical to those by Taiwan race 23,

22, 24 and 26, respectively.

3) Fourteen isolates representing 14 Taiwan races were tested on U.S. and Japanese differentials. It seemed that the U.S. differentials did not provide a satisfactory differentiation for the Taiwan races. They failed to distinguish between race 13 and 16, race 9 and 22 or 24, race 14 and 17 or 19. On U.S. differentials, Taiwan race 5, 12, 14, 13 or 16, and 17 showed identical or similar pattern of U.S. race 6, 21, 4, 17 and 2, respectively. The 14 Taiwan races were unequivocally separated from one another on the Japanese differentials. On Japanese differentials, Taiwan race 12, 17, and 22 showed identical pattern of Japanese N-6, N-2, and N-1, respectively.

4) Some representative Taiwan races were tested on the 12 and 24 tentative international differentials supplied by USDA and IRRI respectively. In general, Taiwan races showed rather weak pathogenicity to these differential varieties. These sets of differen tials seemed not to provide a satisfactory differentiation for the Taiwan races.

5) Nine isolates representing nine Taiwan races of *P. oryzae* were tested on the 40 rice varieties supplied by FAO. All test isolates induced resistant reaction on varieties of group 1. Most of the varieties in groups 2 and 3 showed R reactions to the test isolates. Varieties in groups 4 and 5 showed inconsistent reactions. S reaction was caused by all the isolates in varieties of group 6.

6) Twenty commercial rice varieties were tested for their reactions to eight Taiwan races of *P. oryzae*. Among these varieties, only Taichung 186 and Taichung-yu 184 are resistant to all the races tested. The rest of the varieties are susceptible to most of the test isolates.

7) Several races of *P. oryzae* were obtained from one paddy field block consisting of one rice variety-Taichung 65. Races belonging to T race group were found to be the most prevalent ones.

8) The eight international differential varieties were tested for their reactions to the isola tes of *P. oryzae* which had been characterized with U.S., Japanese or Taiwan set of differentials, and to new isolates of the pathogen from Taiwan. Most of the former Taiwan races and newly collected isolates were included in IG and IH groups. Prior and new nomenclature designations for the former US and Japanese races are: US 1A=IB-5; US 5A, and US 6B=ID-8; US 7A=IF-1; US 3=IG-1; US 5B=IG-2; US 2 and 4=IH-1; T-1=IC-5; T-2=ID-10; C-1=IE-1; C-3=IF-2; N-1=IG-1; N-2, N-4, and N-5=IH-1.

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PART II

THE VITAMIN, CARBON AND NITROGEN NUTRITION OF *PIRICULARIA ORYZAE* CAV.

S. Y. Lin, and C. C. Chien

Introduction

The existence of physiologic races of the rice blast fungus has been reported from different rice growing countries. (3, 4, 10, 11, 13, 16, 17, 18). In Taiwan, numerous isolates of *P. oryzae* have been characterized into physiologic races on the basis of their pathogenicity to the differential rice varieties (7, 8, 12, 15).

Isolates of *P. oryzae* also differed in their physiologic characteristics such as mycelial growth, pigmentation, conidium production, and nutritional requirement. Several workers (1, 7, 12, 28) compared the cultural characteristics of a number of the rice blast fungal isolates and classified them into different cultural types. Suzuki (24) analyzed a large number of single spore isolates and grouped them into 11 biologic species on the basis of appressorium type. Chien *et al* (7) found that cultural types of the blast fungus were to some extent associated with pathogenicity, but no definite correlation was observed between cultural characters and pathogenic races.

Many workers have studied the effects of carbohydrates (2, 5, 6, 14, 22, 23, 25, 29, 30), nitrogen sources (2, 5, 6, 14, 20, 21, 23, 25, 27, 29) and vitamins (2, 14, 21, 23) on the growth of *P. oryzae*. Among them, Otsuka in Japan, suggested the close relationship between relative strength of pathogenicity and nutrition of the fungus. He assumed that the difference in pathogenicity shown by races of *P. oryzae* was caused by differences in their metabolical mechanism and biochemical properties, and that the differences in utilization of nutrition were considered to be the result of biochemical differences among the strains, and were available as a basis of classification (23). Chen (6) also stated that the sensitivity of *P. oryzae* to the nutritional status of the host was partly due to its specific nutritional requirements. Others workers (14, 30) reported that nutrition of *P. oryzae* varied in different isolates and this variation was similar to the variation in virulence of the isolates to different rice varieties

The primary purpose of the investigations was to study the vitamin, carbon and nitrogen nutrition of *P. oryzae* and to elucidate the possible correlation between nutrition and pathogenicity of the fungus.

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Meterials and Methods

Isolates of *P. oryzae* showing distinct degree of pathogenicity were used. They included ten Taiwan isolates, one Japanese and one U.S. isolate.

The basal medium consisted of KNO_3 2 g, KH_2PO_4 0.5 g, K_2HPO_4 0.5g, $MgS0_4 \cdot 7H_2O$ 0.5 g, $CaCl_2 \cdot 6H_2O$ 0.1 g, $FeSO_4 \cdot 7H_2O$ 0.0075 g, $CuSO_4 \cdot 5H_2O$ 0.007 g, $MnSO_4 \cdot 6H_2O$ 0.002 g, $ZnSO_4 \cdot 7H_2O$ 0.009 g, H_3BO_3 0.0009 g, dextrose 30 g, and distilled water to make up one liter. When the effect of carbon or nitrogen compound on the growth of the fungus was studied, 2 mg. thiamine and 5 μg biotin were added to one liter of the basal medium.

Vitamins were added to give the final concentration indicated: thiamine 2 mg, biotin 0.005 mg, riboflavin 0.5 mg, pyridoxine hydrochloride 0.5 mg, calcium pantothenate 2 mg, p-aminobenzoic acid 0.5 mg, inositol 4 mg, nicotinic acid 5.0 mg, folic acid 0.004 mg, choline chloride 2 mg, and ascorbic acid 0.5 mg in one liter medium. To determine optimum concentration of thiamine and biotin for growth, concentrations listed in Table 4, and 5 were utilized.

The carbon or nitroge sourses were prepared to yield the amount of carbon equivalent to that in 30 g of glucose, and the nitrogen compound equivalent to that in 2 g potassium nitrate oer liter of medium.

All media were sterilized by Seitze filtration, unless . otherwise stated. In preliminary experiments, the solid media were sterilized at 100°C for 30 minutes thrice at 24 hours interval. The pH of media was measured by Leeds pH meter and adjusted to pH 7.0 by adding 1.0 N NaOH. The pH values of the residual liquid media was determined at the end of all experiments.

The fungus was grown in 30 ml of liquid medium contained in 125 ml Erlenmeyer flask. Some experiments were conducted in solid media, which were prepared by adding 2% Difco Bacto-agar and distributed in square flasks.

Inoculum used was a mycelial disc cut from the edge of a 14-day-old colony on the vitamine-free basal medium with a 5 mm cork borer. Stationary cultures were utilized in all experiments. Samples on liquid media were harvested after 20 days incubation at 28°C. The compact mycelial mat was washed several times with distilled water. A water suction pump was used to speed the harvest. The mycelial mat from the quintuplicates were collected respectively. After drying the mycelial mat at 60°C for 24 hours on previously dried and weighed filter paper, the dry weight of mycelium was determined. The results are presented as the average weights of the five replicates in mg dry weight.

To determine spore production on solid media, ten 5 mm diameter mycelial discs were cut from each colony after 7 and 14 days incubation at 28°C, and transferred into a Kahn tube containing one ml distilled water. The mycelial discs in the tube were homogenized and shaken vigorously and spore count was made with a hemocytometer.

Results

Effect of vitamins: In initial experiments to determine which among the 11 vitamins was responsible for the growth and sporulation of the fungus, the media were prepared so

that each of the 11 vitamins was withheld in turn, the other 10 vitamins being present. There are two controls, one the basal medium only, and the other the basal medium containing all 11 vitamins. The results are given in Table 1. Among the 11 vitamins used only biotin and thiamine were influential to the growth of the fungus. Other vitamins were found ineffective. The dependency of the fungus on biotin was greater than on thiamine. In the biotin free medium, most of the isolates showed very slight mycelial growth. Some isolates such as U.S. 5A, 4S-26S, and 4T-28S required much more exogenous biotin than other isolates. They gave almost no growth on biotin-free medium. The dependency of the fungus on thiamine varied from almost a complete requirement to partial requirement depending on the isolates. It was found that a majority of the isolates had a partial requirement for thiamine. Some isolates appeared to have almost no thiamine requirement, whereas most of the other isolates showed varying degrees of deficiency for thiamine. However, no isolate exhibited an absolute requirement for this vitamin. In the thiamine-free medium, isolates 4S-26S and 4C-10S produced as much mycelium as that in "all" medium. Three isolates i.e., 4S-15S, 3C-58G,and 4K-4S produced 1/3-1/2 of mycelial dry weight, and the other four isolates, 0'S-45S, 4T-28S, Ken 60-19 (C-1), and U.S. 5A gave 2/3 growth as compared with that in "all" medium.

In general, isolates of *P. oryzae* in the media devoid of vitamins other than biotin or thiamine produced the dry weight of mycelium as much as in "all" medium. Some isolates, such as isolate 3C-58G for example, produced more dry weight of mycelium in media devoid of ascorbic acid or p-aminobenzoic acid. From these results, it was apparent that none of the fungal isolates showed a multiple vitamin requirement with regard to the 11 vitamins used in this study. Only biotin and thiamine, especially the former, were found to be indispensable to the growth of the fungus.

Sporulation of the fungus varied greatly with isolates and with media. Generally, spores were produced much more abundantly after 14 days incubation. In some instances more spores were produced in the medium devoid of a certain vitamin than in "all" medium. Biotin and thiamine also greatly influenced the sporulation of the fungal isolates. No conidium was produced by any isolates in either biotin or thiamine-free media. It was demonstrated that both biotin and thiamine were absolutely essential for the sporulation of *P. oryzae*. (Table 2)

Table 1. Growth of *P. oryzae* in a basal medium supplemented with different vitamins and glutamic acid.

Vitamin	Isolate									Treatment
	(1) 3C-58G	(12) 4S-15S	(13) O'S-45S	(16) 4S-26S	(20) 4C-10S	(22) 4T-28S	(24) 4K-4S	Ken 60-19 (C-1)	U. S. 5A	mean
All[a]	137[c]	205	144	158	154	150	171	130	122	152.3
All-thiamine	61	68	100	142	118	92	88	89	85	93.7
All-biotin	32	35	35	15	38	19	30	34	3	26.8
All-inositol	173	197	145	178	156	135	180	132	141	159.7
All-riboflavin	163	158	139	175	129	164	175	154	140	155.2
All-calcium pantothenate	179	186	157	156	161	146	183	156	147	163.4
All-ascorbic acid	183	164	142	142	156	157	155	145	131	152.8
All-nicotinic acid	150	200	144	153	181	143	175	143	124	157
All-folic acid	173	206	125	129	147	154	175	162	117	154.2
All-p-aminebenzoic acid	183	219	129	150	184	125	177	143	120	158.9
All-pyridoxine hydrochloride	156	194	134	145	114	141	171	113	126	143.8
All-choline chloride	164	174	137	98	165	144	161	126	138	145.2
Basal media only	13	36	5	2	27	8	41	21	5	17.6
B.M.[b]+thiamine+biotin	139	296	131	171	157	160	181	137	138	167.8
B.M.+thiamine+biotin+glutamic acid	170	200	131	103	181	152	200	160	131	158.7
Isolste mean	138.4	169.2	119.9	127.8	137.9	126	150.9	123	111.2	

a Basal medium plus 11 vitamins.
b The basal medium.
c Dry weight of mycelium in mg.
L.S.D. 0.05 between treatments=19.2
0.01 between treatments=25.5
L.S.D. 0.05 between isolates=21.8
0.01 between isolates=30.4

Table 2. Sporulation of *P. oryzae* in a basal medium supplemented with different vitamins and glutamic acid.

Vitamin	Isolate (1) 3C-58G		(12) 4S-15S		(16) 4S-26S		(20) 4C-10S		(22) 4T-28S		(24) 4K-4S		(26) 5K-33S		U.S. 5A		Treatment mean	
	b	c																
All [a]	0.8	2.4	2.3	3.5	31.2	78.7	2.2	4.3	26	12.8	0.8	14.7	1.9	9.3	26.1	113.5	11.41	29.9
All−thiamine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All−biotin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All−inositol	0.9	1.5	5.1	7.0	27.6	33.8	2.8	9.1	51.3	30	1.6	21.6	3	3.4	13.6	132	13.24	31.05
All−riboflavin	2.2	1.2	6.2	8.2	50.7	30.6	5.5	2.2	28.5	18.8	2	16.1	0.8	5.3	35.1	139.1	16.38	27.69
All−calcium pantothenate	1.2	2.1	4.3	4.5	30.0	27.3	2.2	1.5	37.6	15.6	2.8	11.8	1.9	4.3	16	105.4	12	21.56
All−ascorbic acid	0.5	1.6	9.5	8.3	16.4	114.3	2.1	3.8	24.8	23.9	1.5	32	0.7	11.9	35.5	140.9	11.38	32.59
All−nicotinic acid	1.2	2.5	5.6	6.4	43.2	24.1	4.9	3.3	21.8	20.1	0.5	19.8	0.5	4.6	19.7	151.7	12.18	29.06
All−folic acid	2.3	1.5	4.5	6.4	49.8	17.1	1.3	1	28.5	35.8	3.6	24.1	2.5	9.4	82.7	138.7	21.9	39.25
All−p−aminobenzoic acid	0.9	2.3	5.2	5.5	45.7	88.3	2.5	5.2	35.5	32.4	1.7	15.7	1.6	2.8	23.8	109.5	14.61	32.71
All−pyridoxine	0.8	2.4	7.2	8.2	27.8	43.6	5.3	8.8	33.3	19.5	1.9	20.7	3.0	5.6	15.3	114.4	11.83	27.9
All−choline chloride	1.4	1.5	5.5	6.0	29.7	25.8	3	4.9	37.1	34	5.7	16.3	2.3	3.2	6	76	11.34	20.96
B.M. only	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B.M.+thiamine+biotin	0.9	2.2	4.8	5.0	14.9	44.2	4.8	7.4	27	32	2.4	15.5	0.8	8.5	4.9	11.8	7.56	15.83
B.M.+thiamine+biotin+glutamic acid	0.6	1.1	9.5	12.2	15.7	6.3	5.5	16.3	13.6	49.2	0.6	7.3	0.4	17.5	17.3	121.9	9.03	28.98
Isolate mean	0.9	1.5	4.7	5.4	25.5	35.6	2.8	4.5	24.3	21.6	1.7	14.4	1.9	6.4	19.7	90.3		

a Basal medium plus 11 vitamins.
b Number presented in 20 thousands of conidia produced on ten 5mm diameter agar discs after one week incubation.
c Number of conidia produced after two weeks incubation.

One week incubation:
L.S.D 0.05 between treatments=35.18
0.01 between treatments=46.79
no significant differences between isolates

Two weeks incubation:
L.S.D 0.05 between treatments=11.26
0.01 between treatments=34.84
L.S.D. 0.05 between isolates=13.21
0.01 between isolates=43.47

In subsequent experiments, vitamin was individually added to the basal medium which contained thiamine and biotin. All isolates gave 1/2—2/3 mycelial growth in the medium with biotin alone, as compared with those in the medium containing both thiamine and biotin. In the medium devoid of biotin, isolates 4T-28S and U.S. 5A showed almost no growth, the rest of the isolates, gave only slight growth. Addition of any other vitamin in the medium containing biotin and thiamine did not further increase the fungal growth. This fact clearly indicated that no appreciable growth was secured with a single vitamin other than biotin and thiamin. When biotin was used in association with thiamine, the fungal growth was greatly increased. (Table 3).

It may be concluded that biotin was indispensable to the growth of the fungus. Thiamine was only a complimentary growth factor. In the absence of thiamine, several isolates of the fungus were able to make fairly abundant mycelial growth but failed to produce spores. Thus, thiamine was more important for sporulation than for vegetable growth. Thiamine alone could exert certain degree of mycelial growth in some isolates, yet thiamine effected fungal growth and especially sporulation only when a sufficient amount of biotin was present in the medium.

Leaver *et al* (19) reported that both thiamine and biotin were essential for growth of the fungus and that the optimum concentration of biotin was 1.0-10 μg/1. Otani (21) stated that biotin was essential for the growth of *P. oryzae*, its optimum concentration being 2.3-3.0 μg/1. In our studies, the minimum concentration of biotin for the optimum growth of *P. oryzae* was 0.5 μg/1, and of thiamine was 0.02 mg/1. Below these concentrations, the growth of the fungus was drastically reduced. (Table 4, Table 5). It was noted that different isolates of the fungus required different amounts of the same vitamin for optimum growth, however, no significant difference in the growth of a given isolate was observed

Table 3. Growth of *P. oryzae* in a basal medium supplemented with biotin, thiamine and other vitamins

Vitamin	Isolate						Vitamin mean
	(1) 3C-58G	(13) 0'S-45S	(22) 4T-28S	(24) 4K-4S	(26) 5K-33S	U.S. 5A	
B.M.[a]	15[c]	10	5	14	20	8	12
B.M.+biotin	65	102	100	88	77	94	87.7
B.M.+thiamine	28	24	8	27	16	5	18
B.M.+B.T.[b]	188	159	197	187	182	177	181.7
a+b+inositol	171	157	180	191	200	185	180.7
a+b+riboflavin	131	158	194	177	180	188	171.3
a+b+calcium pantothenate	196	142	171	178	176	171	172.3
a+b+ascorbic acid	160	159	185	205	215	156	180
a+b+nicotinic acid	156	167	201	197	188	166	179.2
a+b+folic acid	165	165	184	226	186	153	179.8

a+b+P−aminobenzoic acid	170	188	186	164	190	187	180.8
a+b+pyridoxine hydrochloride	187	145	176	166	179	182	172.5
a+b+cholinc chloride	187	195	186	150	188	150	176
Isolate mean	139.9	136.2	151.8	151.5	153.6	140.2	

a. The basal medium
b. Biotin and thiamine
c. Dry weight of mycelium in mg.
L.S.D. 0.05 between treatments=23.70
0.01 between treatments=31.52
L.S.D. 0.05 between isolates =29.38
0.01 between isolates =42.11

Table 4. The influence of biotin concentration on the growth of *P. oryzae*.

concentration (μg/l.)	(1) 3C-58G	(13) 0'S-45S	(22) 4T-28S	U.S. 5A	Biotin concentration mean
5,000	218[a]	220	210	142	197.5
500	264	220	215	138	209.3
50	200	216	214	128	189.5
5	239	215	195	126	193.8
0.5	125	160	207	144	159.0
0.05	45	52	42	30	42.3
0.005	45	47	25	39	39.0
0.0005	48	45	20	30	35.8
Isolate mean	148	146.9	141	97.3	

a. Dry weight of mycelium in mg.
L.S.D. 0.05 between treatments=39.67
0.01 between treatments=53.97
L.S.D. 0.05 between isolates =48.91
0.01 between isolates =72.01

Table 5. The influence of thiamine concentration on the growth of *P. oryzae*.

concentration (mg/l.)	(1) 3C-58G	(13) 2C-2124S	(22) 4T-28S	U.S. 5A	Thiamine concentration mean
20	220[a]	285	195	186	221.5
2.0	213	310	190	213	231.5
0.2	143	256	185	147	182.8
0.02	95	200	95	105	123.8
0.002	84	120	95	72	92.8
0.0002	56	65	92	62	68.8
Isolate mean	135.2	206	142	130.8	

a. Dry weight of mycelium in mg.
L.S.D. 0.01 between treatments=39.49
0·01 between treatments=54.69
L.S.D 0.05 between isolates =44.80
0.01 between isolates =65.00

with either biotin or thiamine in concentrations above minimum requirement. The minimum requirement of biotin for isolates 3C-58G and 0'S-45S was 5 $\mu g/1$, and for isolates 4T-28S and U.S. 5A, 0.5 $\mu g/1$. (Table 4). The minimum requirement of thiamine for isolate 3C-58G was 2 mg/1, for isolates 4T-28S and U.S. 5A, 0.2 mg/1, and for isolate 2C-2124S, 0.02 mg/1 (Table 5.).

Effect of carbon sources: The results of carbon nutrition of *P. oryzae* are given in Table 6. The ability of most of the isolates to utilize certain carbon compounds were relatively similar in many instances. Most of the isolates well utilized glucose, sucrose, fructose, starch, maltose, and lactose, and the variation in utilization of these compounds among the isolates was not great. The ability to utilize galactose, dextrin, and glycerol, however, differed with isolates. Galactose was a poor carbon source for most of the isolates, yet its utilization by isolate 3C-58G and 4C-26S was satisfactory. Sorbose was also unsuitable for the fungus growth. Raffinose supported only moderate growth of the fungus. Among polysaccharides tested, only starch was a suitable carbon source for all isolates, while inulin and cellulose were not Dextrin was utilized moderately by all isolates. Alcohols and organic acids were the poor sources of carbon. It was of interest to note that isolate 6C-34S utilized cellulose and glycerol far better than the rest of the isolates. These two compounds were poorly utilized by the rest of the isolates. Rather fluctuating results were shown when xylose, lactose and starch were used as carbon sources. There were no apparent differences in the utilization of single carbon source by the ten isolates. Differences in the growth of a single isolate were recorded, however, when it was grown on different carbon sources.

Effects of nitrogen sources: In the present studies, various nitrogen compounds were utilized to varying extent by 10 isolates of the fungus (Table 7). Among the inorganic nitrogen compounds, nitrate was utilized very well by all isolates, even nitrite was shown as a good nitrogen scurce for the fungus growth. On the other hand, poor growth of the fungal isolates occurred in the ammonium form of nitrogen sources. Suitability of nitrate-N over ammonium-N was reported by Tanaka *et al.* (27), who stated that the inferiority of ammonium-N was caused by the fall of pH in the medium. In our studies, it was the only exception that isolate 5K- 33S produced large amount of mycelium when NH_4Cl was used as the nitrogen source. Urea was also a suitable nitrogen source. All isolates, except 5K-33S, showed good growth in the medium containing urea. Among amino acid tested, glutamine, glutamic acid, asparagine, aspartic acid, leucine, glycine, and serine were well utilized by all isolates. Most isolates utilized alanine and proline to some extent, while poor utilization was shown by 2K-27S in alanine and by 3C-58G in both amino acid media. Utilization of histidine, valine, arginine and methionine, varied with isolates. Tryptophane was utilized well by all isolates with the exception of 4T-28S. Cystein was the most unsuitable nitrogen source for the growth of all isolates. Peptone and casein hydrolysate were also found to be the suitable nitrogen sources. There were no apparent differences among the isolates when the utilization of nitrogen compounds were considered. There were, however, notable differences in yield of mycelium obtained with the different nitrogen compounds for a given isolate.

Table 7. Utilization of nitrogen sources by 10 isolates of *P. oryzae*

Nitrogen source	Isolate										Nitrogen source mean
	(1) 3C-58G	(3) 2K-27S	(12) 4S-15S	(13) 0'S-45S	(16) 4S-26S	(22) 4T-28S	(24) 4K-4S	(26) 5K-33S	6C-34S	U.S. 5A	
KNO_3	200[b]	210	212	234	183	157	110	110	195	212	183.2
$NaNO_3$	182	202	206	247	177	175	140	133	165	210	183.7
$NaNO_2$	195	202	187	133	236	160	152	207	169	192	183.3
NH_4Cl	65	50	70	47	45	30	64	148	29	30	57.8
NH_4NO_3	60	50	84	53	40	38	60	62	50	48	54.5
$(NH_4)_2SO_4$	50	45	96	65	78	70	60	52	51	81	64.8
Urea	110	120	174	141	140	151	117	58	178	190	137.9
Glutamic acid	226	240	234	215	194	166	124	116	155	225	189.5
Glutamine	171	190	165	242	187	276	168	161	173	236	196.9
Aspartic acid	181	197	240	280	212	280	149	196	187	278	220.0
Asparagine	203	222	201	270	180	174	114	205	200	254	202.3
Histidine	123	111	94	85	57	80	64	75	79	159	92.7
Valine	76	50	111	203	95	94	163	93	60	86	103.1
Alanine	75	89	236	218	112	188	147	201	235	176	167.7
Proline	85	285	181	158	158	222	188	268	173	236	195.4
Leucine	185	203	190	162	108	190	176	235	190	273	191.2
Glycine	240	219	160	156	213	200	173	240	123	232	195.6
Arginine	86	50	152	142	136	180	62	100	70	98	107.6
Methionine	60	52	180	151	80	158	80	186	100	102	114.9
Tryptophane	165	126	171	175	108	85	175	138	192	153	148.8
Serine	188	123	157	220	201	189	178	236	173	212	187.7
Cystein	65	55	77	86	40	23	21	32	30	25	45.4
Casein hydrolysate	176	134	182	196	160	140	154	158	163	120	158.3
Peptone	160	153	189	226	125	106	169	130	164	180	160.2
Control[a]	42	14	18	38	38	21	20	38	25	18	27.2
Isolate mean	138.3	139.3	158.7	165.7	132.1	142.1	121.1	143.1	133.2	161.0	

a. The control medium contains no nitrogen compound.
b. Dry weight of mycelium in mg.
L.S.D. 0.05 between treatments = 25.75
0.01 between treatments = 30.83
L.C.D. 0.05 between isolates = 31.49
0.01 between isolates = 40.10

Table 6. Utilization of carbon sources by 10 isolates of *P. oryzae*

Carbon sources	Isolate										Carbon source mean
	(1) 3C-58G	(3) 2K-27S	(12) 4S-15S	(13) 0'S-45S	(16) 4S-26S	(22) 4T-28S	(24) 4K-4S	(26) 5K-33S	6C-34S	U.S. 5A	
Glucose	203[c]	175	210	215	167	149	184	169	189	200	186.1
Fructose	170	181	187	142	194	173	204	193	181	222	184.7
Galactose	160	29	43	59	120	22	55	37	35	36	59.6
Sorbose	50	30	29	42	47	62	30	36	24	34	33.4
Xylose	125	112	108	79	114	155	150	164	210	205	142.2
Sucrose	228	189	248	210	200	159	195	214	200	213	205.6
Maltose	160	172	151	125	227	137	172	190	194	148	167.6
Lactose	178	155	114	156	108	99	84	105	143	107	124.9
Raffinose	90	64	80	70	68	93	94	100	61	87	80.7
Starch	263	134	216	256	178	166	195	127	153	123	181.1
Dextrin	105	95	105	116	80	95	65	95	93	92	94.1
Inuline	30	28	41	47	53	42	33	38	28	52	40.1
Cellulose[a]	8	10	35	43	35	22	21	6	72	26	27.8
Mannitol	45	40	85	20	40	27	23	42	28	92	44.2
Glycerol	25	40	40	13	34	74	27	40	123	78	49.4
Na-Succinate	95	50	35	37	56	29	30	39	45	33	44.9
Na-Citrate	79	40	31	35	60	24	25	50	21	19	38.4
Control[b]	13	5	10	14	20	8	15	10	12	8	11.5
Isolate mean	112	86.7	99.3	95.3	101.4	85.3	90.2	91.9	102.3	98.6	

a. The medium was sterilized at 100° C for 30 minutes thrice at 24 hours interval.
b. Control medium contains no carhon compound.
c. Dry weight of mycelium in mg.
L.S.D. 0.05 between treatments = 24.92
0.01 between treatments = 32.99
L.S.D. 0.05 between isolates = 28.27
0.01 between isolates = 39.37

Discussion

Studies on vitamin nutrition of *P. oryzae* showed that among the eleven vitamins tested only biotin and thiamine were influencial to the growth and sporulation of the fungus. The fungus seemed to have no requirement for the other vitamins. None of the fungal isolates showed a multiple vitamin requirement with regard to the 11 vitamins used in this study. It was found that dry weights of mycelia produced by the isolates in the biotin-free medium and in the basal medium were almost the same, while more mycelia was produced in the thiamin-free medium. The results that isolates of *P. oryzae* required biotin as an indispensable growth factor, and thiamine as a complimentary growth factor coincided with the results obtained by the other workers (21, 23, 26). Most isolates absolutely required an exogenous supply of biotin. Some isolates had only a negligible requirement for thiamine. Different degree of deficiency for biotin or thiamine may reflect different rates of synthesis of these vitamines in the fungal mycelium. Cochrane (9) stated that fungi not requiring or requiring only a negligible amount of exogenous supply of a vitamin must synthesize the compound and that partial deficiencies for a vitamin are probably more common than absolute or complete deficiencies. When fungi synthesize more of a vitamin that they require for optimum growth, the excess may accumulate in the mycelium or excrete into the culture medium (23). Some isolates produced significantly more mycelium in certain vitamin-free medium than in "all" medium. This might be due to the suppressing factor of the vitamin on the growth of the fungus. It needs further study to clarify whether or not these suppressing effects are present.

From the results of sporulation test, it was clearly shown that biotin and thiamine are absolutely essential for the sporulation of *P. oryzae*. In the absence of these two vitamins, several isolates were able to make some mycelial growth, but failed to produce spores. Apparao (2) also found that larger quantities of thiamine and biotin were required for sporulation than for growth. Sporulation of the fungus varied greatly with isolates and with media, yet, to what degree the vitamins other than thiamine and biotin influenced the sporulation of the fungus is not clear.

Otsuka (23) indicated that the requirement of biotin, thiamine and nicotinic acid of strains of *P. oryzae* was closely related to the relative strength of pathogenicity. According to him the majority of isolates which grew only in medium containing both biotin and thiamine were considered to have medium or strong pathogenicity. A few isolates which grew in media devoid of either biotin or thiamine had weak or no pathogenicity. Isolates with strong pathogenicity generally grew in the medium containing biotin and nicotinic acids. In the present study, because of limited number of test isolates, it seemed too early to draw the conclusion. Nevertheless, from our results, it could be inferred that no clear correlation was observed between the pathogenicity and vitamin requirement of the rice blast fungus.

Many workers have studied the carbon nutrition of *P. oryzae*. In general, organic acids

were not suitable carbon sources for the fungus (14, 22, 30). The same results were obtained in our studies. Otani (22) however, reported that glucose, inulin and mannitol, as well as organic acid such as succinic acid are the most excellent carbon sources for the fungus growth. Inulin and mannitol were found to be a poor carbon sources by the present writers. Glycerol was regarded as an unsuitable nutrient by Tomizawa (29), but was reported as an excellent carbon source by Tanaka (25). In our studies, it was noted that most isolates were unable to utilize glycerol, with the exception of isolate 6S-34S which utilized glycerol quite well. According to Otani (22), lactose was unfavorable carbon source. Other workers, however, reported that lactose was well utilized by the fungus (5, 6, 14, 23). Xylose was reported as a suitable carbon source by several workers (14, 22). It was also found to be a relatively poor source of carbon (30). In our studies, all isolates, except 0′S-45S, utilized xylose to a certain extent. Otsuka (23) indicated that there were marked differences among strains in utilization of sorbose, inulin and mannitol. According to him the strongly pathogenic group were inulin, cellulose utilization positive and sorbose utilization negative, and those strain which showed weak pathogenicity belonged to inulin, cellulose utilization negative, sorbose utilization positive group. Chen (5) also reported that isolates showed higher ability in cellulose utilization gave higher pathogenicity. In our studies, there were no apparent differences in the utilization of these carbon sources by the isolates, although utilization of cellulose somewhat differed with isolates.

The blast fungus utilized a wide variety of inorganic and organic nitrogen compounds. In the present study, nitrate and nitrite nitrogen was superior to ammonium nitrogen. $NaNO_2$ was found to be unfavorable for the growth of the fungus (5, 20, 21). Otsuka (23) reported that some strains of the blast fungus grew well in a medium containing $NaNO_2$, while others did not. He stated that strains that did not utilize $NaNO_2$ or utilize it poorly, mostly showed strong pathogenicity, while those strains that utilized it well showed weak pathogenicity. In the present studies, all isolates tested utilized $NaNO_2$ satisfactory, and the difference among isolates was not apparent. Many workers (14, 20, 21) reported that ammonium-N was unsuitable nitrogen source. Tanaka (27) ascertained that the inferiority of ammonium-N was caused by the fall of pH value in the medium. By contrast, Chen (6) stated that ammonium salts were more favorable inorganic N sources than nitrate. Among amino acid tested, glutamine, glutamic acid, asparagine, aspartic acid, leucine, glycine, and serine were well utilized by all isolates. These results are similar to those reported elsewhere (5, 14, 20, 23). Generally, the leaves of susceptible rice plant have higher content of amino acids (25). This may suggeste a possible relationship between the growth responses of *P. oryzae* in culture to amino acids and the establishment of the fungus in the host. It was pointed out by Otsuka (23) that strain of strong pathogenicity generally utilized trytophane poorly, while those of weak pathogenicity generally utilized it well. In our studies, however, no difference in tryptophane utilization was observed among isolates of different pathogenicity. Most isolates utilized tryptophane well, with the exception of isolate 4T-28S. No clear correlation was found between utilization of nitrogen or carbon compounds and the virulence of the isolates.

Summary

Vitamin requirement for growth and sporulation of a certain isolates of *Piricularia oryzae* Cav. were determined. Of the vitamins studied, only biotin and thiamine were essential to the growth of the fungus. Other vitamins were found ineffective. The dependency of the fungus on biotin was greater than on thiamine. All isolates tested required exogenous biotin for mycelial growth. It was found that a majority of the isolates had a partial requirement for thiamine. No isolates exhibited an absolute requirement for thiamine. Both biotin and thiamine were absolutely essential for the sporulation of *P. oryzae*. No conidia were produced by any isolate in either biotin or thiamine free media. In the absence of thiamine, several isolates of the fungus were able to make fairly abundant mycelial growth, but failed to produce spores. The minimum concentration of biotin for the optimum mycelial growth of the fungal isolates was 0.5 $\mu g/l$, and of thiamine, 0.02 mg/l. Below these concentrations, the growth of the fungus was drastically reduced. No correlation was observed between pathogenicity and vitamin requirement of the fungus.

The effects of different carbon and nitrogen compounds upon the growth of the fungus were also studied. The best carbon sources for all isolates were glucose, sucrose, fructose, starch, maltose, lactose and xylose. Raffinose was utilized moderately by all isolates. Galactose and Sorbose were found to be unfavorable for most of the test isolates. Alcohols and organic acids were the poor sources of carbon. With the exception of starch, all polysaccharides studied were unfavorable for the fungus growth. Utilization of cellulose by isolates 6C-34S, 0′S-45S and 4C-15S was somewhat better than the other isolates. Dextrin supported only moderate growth of the fungus. Among the inorgainc nitrogen tested, nitrate and nitrite nitrogen were superior to ammonium. Several amino acids such as glutamine, glutamic acid, asparagine, aspartic acid, leucine, glycine, and serine were well utilized by all isolates. Cystein was the most unfavorable amino acid tested. Tryptophane was utilized well by all isolates with the exception of 4T-28S. Most isolates utilized alanine and proline to some extent. Utilization of histidine, valine, arginine and methionine varied with isolates. There were no apparent differences among the isolates when the utilization of nitrogen and carbon sources were considered.

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稻熱病同一病斑所得菌株病原性之研究*

簡 錦 忠

前 言

稻熱病病原菌 (*Piricularia oryzae* Cav.) 之生理分化與病原性變異問題之研討，在稻作抗稻熱病育種與檢定試驗方面言之，無疑是個重要而亟須先行探明之課題，蓋欲以一病原性不穩定之病原菌供作一未知抗病程度之稻品種抗病性測定，為一不可能之舉。有關稻熱病病原菌 race 之問題佐佐木氏 (1922—1923) (5) 首先報告其分化現象之存在，Tochinai, Chimamura (1932) (8) 從其供試41稻熱病病原菌株中，分別歸納為九種培養型，鈴木氏 (1963) (7) 曾以同一稻熱病病斑所得許多單胞後代中，以胞子發芽之形態，附着器 (Appresorium) 於不同溫度下之發芽情形等之不同而歸納為 12 種 homokaryotic type，中西、今村等氏 (1960) (4) 謂於單一病斑上所形成之病原胞子，有時混有不同病原性之存在。

於本省，有關稻熱病病原菌生理小種之研究，已進行數年，從省內各稻作栽培區採集罹病標本分離數百菌株，以其對供試16判別稻品種致病性之不同，而歸類為25個不同生理小種 (3, 1, 2)

本試驗之目的為求進一步探討於同一病斑所得菌株之不同單胞間及各單胞前後代之間有無病原性之異同。

本研究進行時，得楊騰金先生之協助，謹誌謝忱。

材 料 與 方 法

a. 供試病原菌：

3K—39S：標本採自高雄區，由花育52號品種之感病型病斑 (S type) 所分離。

3C—1681R：標本採自嘉義區，由外國引進品種之抗病型病斑 (R type) 所分離。

病原菌以酵母澱粉培養基 (Yeast extract 2g., Soluble starch 10g., Dist water 1,000cc)，試管斜面於28°C 培養一星期後，加注無菌水，作成胞子懸浮液，以 Lambertis Method 行單胞分離，將所得單胞菌株先於試管斜面培養一星期，記錄培養型後作成懸浮液，移植四角培養瓶，於 28°C 定溫平面培養14天，供作接種試驗之用。

b. 培養型之記載：依下列標準：

A型：氣生菌絲灰白色，1mm 高，胞子形成極多。

B型：氣生菌絲灰白色，1mm 高，胞子形成少。

C型：菌落鐵灰色，輪紋狀，上有白色菌塊，氣生菌絲 2mm 高，胞子形成極多。

D型：氣生菌絲灰白色，2mm 高，胞子形成尚多。

E型：氣生菌絲白色，叢簇狀，較粗，3～4mm 高，胞子形成量僅次於 C 型，常產生變異型菌絲。

F型：氣生菌絲淡褐色，1mm 高，胞子形成由少至多，因菌株而異。

c. 病原性之測定：

以崑山五香粳、臺中65號、稗稈稻、臺中171號、嘉農育280號、關東 51 號、農林 21 號、Cutsugulcul 、高雄大粒清油、臺中低脚烏尖等10品種。供作判別稻品種，以鉛製小盤 (7×7×10cm) 盛取本所試驗水田土壤於溫室內，行旱栽並重施氮肥，稻種在催芽播種前以「谷樂生

※本研究之完成得國家長期發展科學委員會之補助。

(Granosan)」1/1,000 倍稀釋液，浸漬消毒，待稻苗生長達本葉 3 ～ 4 片時，以噴霧法行人工接種，將病原菌分生胞子懸浮液均勻噴射於稻葉表面，置適當溫度與濕度下保持24小時後移置溫室，約經10天，調查感病情形、病斑型態分作感病性 (Susceptible) 中間性 (Moderate) 及抗病性 (Resistant) 等予以記載。

結果與討論

一、培養型：繼代單胞分離各單胞後代於酵母澱粉試管斜面培養基所呈現之培養型列於表一：

表一：供試菌株培養型

Table 1: The variability of cultural type of isolates of *P. oryzae* upon successive single spore transfers.

(A:S 菌株)

培養代數	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10
一	E	D	D	D	D	D	D	E	E	E
二	E	E	E	E	E	D	D	E	E	E
三	E	E	E	E	E	D	D	E	E	E
四	E	E	E	E	E	E	E	E	E	E
五	E	E	E	E	E	E	E	E	E	E

((B:R 菌株)

培養代數	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-9	R-10
一	D	D	D	D	D	D	D	D	D	D
二	D	D	D	D	D	D	D	E	E	D
三	D	D	D	E	D	D	E	E	E	D
四	E	D	D	E	E	E	E	D	E	D

註：S＝自感病性病斑所得菌株 (3K-39S)；R＝自抗病性病斑所得菌株 (3C-1681R)；一、二、三、四、五＝單胞培養代數：1,2,3,4,5,6,7,8,9,10＝單胞菌株代號。

由表一(A)看出在第一代之各號單胞菌株中1,8,9,10等號單胞菌株為E型外，其他各號單胞菌株均為D型。在第二代培養中2,3,4,5各號單胞菌株由D型變為E型，其他仍保持與其前代相同，在三、四兩代之培養中，變異較少，至第五代則每一單胞菌株均已呈E型。單胞菌株6,7號則至第四代才由D 型變為E型。表一(B)中之變化略有所異，其第一代培養各單胞均屬 D 型，第二代中8,9號單胞菌株及第三代中4,7號單胞菌株均由D型變為 E型，第四代中1,5,6等號單胞菌株，由D型變為 E 型， 8號單胞菌株於第四代由E型變為D型。在前後四代培養中2,3,10等號單胞菌株均始終呈D型。

表二、各代單胞對判別稻品種之感病情形

Table 2: Pathogenic reaction of ten differential rice varieties to isolatos of *P. oryzae* upon successive single spore transfers.

a：感病型菌株 (S)

判別稻品種	S-1					S-2					S-3					S-4					S-5					S-6					S-7					S-8					S-9					S-10				
	一	二	三	四	五	一	二	三	四	五	一	二	三	四	五	一	二	三	四	五	一	二	三	四	五	一	二	三	四	五	一	二	三	四	五	一	二	三	四	五	一	二	三	四	五	一	二	三	四	五
崑山五香粳	S	S	S	S	S	S	S	S	R	R	S	S	S	S	S	S	S	S	S	S	S	R	R	R	R	S	S	S	S	S	S	S	S	S	R	S	S	S	S	S	S	S	S	S	S	S	M	M	M	M
臺中65號	S	S	S	S	S	S	S	S	S	R	S	S	S	R	R	S	S	S	M	M	S	S	S	S	S	S	R	R	R	R	S	R	R	R	R	S	S	S	S	M	S	S	S	S	S	S	M	M	M	M
稗稈稻	S	S	R	R	R	S	R	R	R	R	S	R	R	R	R	S	R	R	R	R	S	R	R	R	R	R	R	R	R	R	S	R	R	R	R	S	S	R	R	R	S	M	M	M	M	S	R	R	R	R
臺中171號	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
嘉農育280號	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
關東51號	M	R	R	R	R	S	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
農林21號	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Cutsugulcul	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	S	R	R	R	R	R	R	R	R	R	S	R	R	R	R	S	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	R
高雄大粒清油	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
臺中低脚烏尖	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	M	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R

b. 抗病型菌株 (R)

判別稻品種	R-1 一	R-1 二	R-1 三	R-1 四	R-2 一	R-2 二	R-2 三	R-2 四	R-3 一	R-3 二	R-3 三	R-3 四	R-4 一	R-4 二	R-4 三	R-4 四	R-5 一	R-5 二	R-5 三	R-5 四
崑山五香粳	S	S	S	S	S	S	S	S	S	S	R	R	S	S	R	R	S	S	S	M
臺中65號	S	S	S	S	S	S	S	S	S	S	R	R	S	S	R	R	S	S	M	M
稗稈稻	S	S	R	R	S	S	S	S	S	R	R	R	R	R	R	R	M	M	R	R
臺中171號	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
嘉農育280號	R	R	R	R	R	R	R	R	M	R	R	R	R	R	R	R	R	R	R	R
關東51號	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
農林21號	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Cutsugulcul	S	R	R	R	S	S	R	R	S	S	R	R	S	S	R	R	S	S	R	R
高雄大粒清油	S	S	R	R	M	R	R	R	S	S	R	R	R	R	R	R	R	R	R	R
臺中低脚烏尖	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	S	R	R

判別稻品種	R-6 一	R-6 二	R-6 三	R-6 四	R-7 一	R-7 二	R-7 三	R-7 四	R-8 一	R-8 二	R-8 三	R-8 四	R-9 一	R-9 二	R-9 三	R-9 四	R-10 一	R-10 二	R-10 三	R-10 四
崑山五香粳	S	S	R	R	S	S	S	S	M	M	R	R	R	R	R	R	S	S	R	R
臺中65號	R	R	R	R	S	S	S	S	R	R	R	R	S	S	S	S	S	S	S	S
稗稈稻	M	R	R	R	R	R	R	R	S	S	S	R	R	R	R	R	M	R	R	R
臺中171號	R	R	R	R	M	M	M	M	R	R	R	R	R	R	R	R	R	R	R	R
嘉農育280號	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
關東51號	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
農林21號	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Cutsugulcul	R	R	R	R	R	R	R	R	S	S	R	R	S	R	R	R	R	R	R	R
高雄大粒清油	R	R	R	R	S	R	R	R	R	R	R	R	S	S	R	R	R	R	R	R
臺中低脚烏尖	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	S	M	R	R

註：S:感病型病斑　　一、二、三、四、五：培養代數
R:抗病型病斑　　1.2.3………10：單胞菌株代號

由表二(a)可看出，自感病性(S)病斑所得菌株之10單胞培養第一代之病原性對崑山五香粳、臺中65號均呈感病性病斑，對臺中171號、嘉農育280號、農林21號、高雄大粒清油均呈抗病性病斑，此外對稗稈稻、關東51號、Cutsugulcul、臺中低脚烏尖之致病性不盡一致，但 S-5 與S-10, S-4 與 S-9, S-1 與 S-8 之致病反應一致，於培養第二代之病原性已有一部份轉弱，於第一代呈感病反應而第二代呈抗病反應者，除 S-1 及S-8 之外均有此現象。於第三代培養中，除 S-1, S-8 對稗稈稻之病原性由感病型轉弱爲抗病型以外，其餘各單胞之致病反應一如其前代。第四代培養中，S-2 對崑山五香粳及 S-3 對臺中65號之致病性由感病型轉呈抗病型，S-4 對臺中 65 號由感病型轉呈中間型 (M)，此外各單胞並無變化。在第五代培養中，S-2 對臺中 65 號，S-7 對崑山五香粳均由感病型轉呈抗病型，S-8 對臺中65號由感病型轉呈中間型。

在前後五代單胞培養中，S-1, S-3, S-4, S-6, S-8, S-9 對崑山五香粳及 S-1, S-3, S-5, S-9 對臺中65號均保持感病型致病反應。對所有供試判別品種言之，S-2 與 S-7 均呈抗病型反應，爲病原性較弱之顯著者，S-1 與 S-9 除對稗稈稻之反應不同外，對其他各品種之致病力爲一致，此兩單胞爲保持較强之致病性者，S-3 與 S-6, S-4 與 S-8 對各品種之致病反應爲一致，對崑山五香粳呈感病型對臺中65號呈抗病型或中間型。

表二 (b) 爲抗病型 (R) 病斑所得菌株。在其第一代培養各單胞菌株中對崑山五香粳與臺中65號，除 R-6, R-8, R-9 以外均呈感病性病斑，對嘉農育280號，關東51號，農林21號及臺中171號等品種，除 R-1, R-3 及 R-7 略差異型外均呈抗病性反應，此外對稗稈稻、Cutsugulcul、高雄大粒清油、臺中低脚烏尖等品種之致病反應亦不一致。在第二代培養中，R-1 對臺中171號，Cutsugulcul, R-3 對稗稈稻，R-7 對高雄大粒清油，R-9 對臺中低脚烏尖等品種之致病性均由感病型轉呈抗病型，而 R-2 對高雄大粒清油，R-3 對嘉農育280號，R-6, R-10 對稗稈稻，乃由中間型轉呈抗病型，由感病型轉呈中間型者僅 R-10 之對臺中低脚烏尖。在第三代培養中，由感病型轉呈抗病型者有 R-1 對稗稈稻及高雄大粒清油，R-2, R-3, R-4, R-5, R-8 對 Cutsugulcul, R-1, R-3, R-9 對高雄大粒清油，R-4 對崑山五香粳，R-5 對稗稈稻及 R-10 對臺中低脚烏尖，而 R-5 對臺中65號爲由感病型轉呈中間型。在第四代培養中，變化轉少，僅 R-5 對崑山五香粳由感病型轉呈中間型，及 R-8 對稗稈稻由感病型呈抗病型。

上述復以表列方式列於表三。

據上述可知自田間 (自然界) 採取稻熱病標本，選呈感病性病斑或抗病性病斑，經單胞分離後，其後代隨機選10個單胞培養，經四或五代觀察其培養型，兩者之間無一定的形態之別。又將每一代之病原接種於10判別稻種，測定其致病反應結果，自感病型所得菌株 (3K-39S) 對10判別稻種中之四種 (臺中171號、嘉農育280號、農林21號、及高雄大粒清油) 均呈抗病性，而在第一代之致病反應呈感病性反應者，如果是抗病性强之稻種，至第二代之病原多半呈爲抗病性反應，反之判別稻種中抗病性極弱之稻種 (崑山五香粳、臺中65號) 其變化較少，如 S-1, S-9 對該兩種品種雖經培養五代，各代之致病反應呈感病性，又 S-3, S-4, S-6, S-8 等對崑山五香粳各代均呈感病性反應。再者自抗病性病斑 (R) 所得菌株 (3C-1681R) 對10判別稻種之致病反應，對10判別稻種中之 3 品種 (嘉農育280號、關東51號、農林 21 號)，均呈抗病性反應外，其他 7 種判別稻種都有感病性反應之存在。但在第一代之致病反應呈感病性反應而第二代則大部份轉呈抗病性反應，其傾向與自感病性病斑所得菌株相同。

總而言之，自感病性病斑所得菌株對10判別稻種之致病反應，不能全部呈感病性反應，又自抗病性病斑所得菌株對判別稻種之致病反應亦未能均呈抗病性反應，而且兩者之菌株繼代培養時其病原性都有遞減之傾向。又病原菌之培養型與病原性之關係並無一定的直接關係。故欲獲繼代培養菌之病原性一定不變，需待今後之再檢討。

表三：同一病斑所得各單胞培養於不同代數所呈病原性之轉變

Table 3: The variability of virulece of isolatos of *P. oryzae* upon successive single spore transfers

供試判別品種	感病型菌株												抗病型菌株								
	二			三			四			五			二			三			四		
	S→M	S→R	M→R	S→M	S→R	M→R	S→M	S→R	M→R	S→M	S→R	M→R	S→M	S→R	M→R	S→M	S→R	M→R	S→M	S→R	M→R
崑山五香粳	10	5						2			7						3 4 10	8	5		
臺中65號	10	6 7					4	3		8	2					5	3 4				
稗稈稻	9	2. 5. 3. 7. 4.10.			1. 8									3	6 10		1	5		8	
臺中171號														1							
嘉農育280號															3						
關東51號		2 6																			
農林21號																					
Cutsugulcul		3.7 4.9 6.												1 9			2.5. 3.8. 4.				
高雄大粒清油														7	2		1. 3. 9.				
臺中低脚烏尖		5 7 10	6										10	9			5	10			

註：二、三、四、五爲培養代數。
S→M由上一代之S型轉呈M型，餘類推
阿拉伯數字代表單胞菌株代號。

摘　　要

1. 本試驗之目的，在於探討自同一病斑分離所得不同單胞病原性之異同與其繼代單胞培養之病原性變異，供試病原菌有 3K-39S 及 3C-1631R 兩菌株，前者係分離自高雄區，花育58號品種之感病型病斑，後者係分離自嘉義區，由外國引進品種之抗病型病斑。各菌株均以10個單胞培養供試。病原性判別稻品種爲崑山五香粳、臺中65號、稗稈稻、臺中171號、嘉農育280號、關東51號、農林21號、Cutsugulcul 、高雄大粒清油及臺中低脚烏尖等10品種。

2. 培養型之鑑定，以氣中菌絲之高度、顏色及胞子形成之多寡爲分類依據。3K-39S 之第一代培養各單胞菌株中有 D 型及 E 型之不同，唯培養至第五代均轉呈 E 型。3C-1681R 之第一代均爲 D 型，而至第四代除 4 個單胞菌絲仍爲 D 型外，其他 6 單胞菌株轉呈 E 型。

3. 自感病型病斑所得菌絲之不同單胞培養對10判別品種之致病反應不能全部呈感病性反應，又自抗病性病斑所得菌絲之不同單胞培養亦不能均呈抗病性反應，而兩菌株在繼代培養中，病原性均有遞減之傾向，又病原菌之培養型與病原性之間並無一定之直接關係。

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STUDIES ON THE PATHOGENICITY OF THE DIFFERENT MONOCULTURES OF *PIRICULARIA ORYZAE* CAV. ISOLATED FROM A SINGLE BLAST LESION

Chin-chung Chien

SUMMARY

1. The present experiment was made to investigate the pathogenicity of the different single-spore cultures of *P. oryzae* Cav. isolated from a single lesion of rice plant, and to examine the variability of their virulence during successive single-spore cultures. Isolate 3K-39S obtained from a lesion of susceptible infection type on variety Hua-yu 58 collected from Kaohsiung area, and isolate 3C-1681R obtained from a lesion of resistant infection ype on a newly introduced variety collected from Chiayi area were subjected to the single-spore isolation. Ten single-spore cultures derived from each isolate were tested for their pathogenicity on ten differential rice varieties by means of artificial inoculation.

2. The culture types of each subculture were classfied on the basis of texture and color of aerial mycelia and sporulation. Four monocultures derived from isolate 3K-39S have transformed from type D to type E, while the others maintained as type E at the fifth generation. Six monocultures of isolate 3C-1681R have changed from type D to type E, while the others remained as type D throughout four generations.

3. The different monocultures originated from the same isolate did not produce the lesions of the same infection type on the differential rice varieties. The pathogenicity of the progenies of the two isolates are not all identical to the pathogenicity of the parental cultures. Generally, the virulence of successive single-spore-cultures decreased from generation to generation. There is no distinct correlation between the culture type and the pathogenicity.

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長粒型秈稻異常發生穗稻熱病之調查及其病原菌生理型之研究[1]

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摘要 民國六十三年第二期作於臺南、嘉義、雲林及南投等四縣栽培之長粒型秈稻（嘉農秈8號及11號）異常發生穗稻熱病，嘉農秈8號之栽培面積1,702.0公頃中，受穗稻熱病爲害者高達74.83%，而嘉農秈11號之栽培面積4,270.3公頃中，發生面積爲28.95%，由此可知其嚴重性。此兩種稻品種發生穗稻熱病之特性，在被害穗之葉節部位受病原菌之侵害（所稱葉節稻熱病）頗普遍。

自被害稻穗分離所得菌株，經對16判別稻種測定結果，可類別爲五羣（Groups），包括21種不同生理小種（Races），其中新出現之生理小種有五種之多。在21種生理小種中，屬於 I 羣者13種，T 羣2種，K 羣4種，N 及 A 羣者各1種。侵害嘉農秈8號及嘉農秈11號之主要稻熱病菌生理型，前者爲 Race55及51，後者爲 Race 51及 31等。由此可知可侵害印度型稻之生理型頗多，今後對稻熱病之發生消長，吾人需特別提高警覺。

前 言

近年來稻作育種家極重視品種間抗病、蟲害之問題，期能育成既抗病蟲害又豐產之優良品種。民國六十二年（1973）嘉義農業試驗分所曾育成長粒型秈稻，嘉農秈8號（係自 IR 661-1-140-3 系統分離）和嘉農秈11號（IR 8 與 IR 9-60雜交）兩品種，其優點係豐產，對葉稻熱病之抵抗力比一般推廣品種強；後者之抗蟲性（對褐飛蝨）頗佳 (4)，是近年來育成品種中最爲成功之稻種。自民國六十三年第一期作推廣後，頗受農民重視及歡迎。但同年第二期作栽培地區（臺南、嘉義、雲林及南投等縣），部份發生嚴重的穗稻熱病，其產量頗受影響。過去本省稻熱病主要發生於第一期作，而第二期作在平地發生極爲輕微，何以長粒型秈稻於第二期作發生穗稻熱病，其與稻熱病病原菌生理型之影響如何，頗有探討之必要。

本試驗進行中，栽培地區的實地發生狀況調查工作係蒙臺南區農業改良場黃杉芪先生及臺中區農業改良場楊涌祚先生負責，始能完成，謹此誌謝。

長粒型秈稻穗稻熱病發生調查

1. 發生面積調查

民國六十三年第二期作長粒型秈稻栽培最多者爲臺南及臺中兩地區。臺南區包括雲林、嘉義及臺南等三縣，由臺南區農業改良場黃杉芪先生負責實地調查。臺中地區主要係南投縣，由臺中區農業改良場楊涌祚先生負責實地調查該地區內秈稻穗稻熱病之發生程度。其結果列於表一。

1.試驗報告農試字第七二九號。

2.臺灣省農業試驗所技正。

表一、臺南、臺中地區六十三年第二期秈稻穗稻熱病發生面積

Table 1. The panicle blast infected acreage in Tainan and Taichung in the second crop of 1974

縣別 Prefecture	鄉鎮別 Town	品種 Varieties	栽培面積(公頃) Cultivated acreage (ha)	穗稻熱病發生面積(公頃) Area of panicle blast infection (ha)				發生面積率(%) Diseased acreage
				輕* Slightly infected	中 Moderately infected	重 Severely infected	計 Total	
雲林 Yun-lin	斗六	嘉農秈8號	549.0	211.0	198.0	140.0	549.0	100.0
		嘉農秈11號	211.0	133.0	50.0	28.0	211.0	100.0
	斗南	嘉農秈11號	432.0	340.0	—	—	340.0	787
	大埤	嘉農秈11號	337.0	30.0	—	—	30.0	8.9
	莿桐	嘉農秈8號	447.6	326.0	72.0	48.0	446.0	99.6
	二崙	嘉農秈8號	83.4	1.0	1.0	1.0	3.0	3.6
		嘉農秈11號	402.1	2.0	—	1.3	3.3	0.8
	小計	嘉農秈8號	1,080.0	538.0	271.0	189.0	998.0	92.4
		嘉農秈11號	1,382.1	505.0	50.0	29.3	584.3	41.6
嘉義 Chia-yi	太保	嘉農秈8號	95.0	25.3	15.4	6.4	47.1	49.6
		嘉農秈11號	856.0	71.8	12.3	3.7	87.8	10.3
	民雄	嘉農秈8號	74.0	23.1	17.1	10.3	50.5	68.2
		嘉農秈11號	188.2	37.6	13.8	6.7	58.1	30.9
	嘉義(市)	嘉農秈8號	180.0	12.0	7.2	1.2	20.4	11.3
		嘉農秈11號	270.0	9.1	1.7	—	10.8	4.0
	小計	嘉農秈8號	349.0	60.4	39.7	17.9	118.0	33.8
		嘉農秈11號	1,314.2	118.5	27.8	10.4	156.7	11.9
臺南 Tai-nan	白河	嘉農秈8號	80.0	6.0	10.0	8.0	24.0	30.0
		嘉農秈11號	300.0	40.0	35.0	15.0	90.0	30.0
	新市	嘉農秈11號	68.0	6.0	—	1.0	7.0	10.3
	歸仁	嘉農秈11號	275.0	1.0	—	0.2	1.2	0.4
	計	嘉農秈8號	80.0	6.0	10.0	8.0	24.0	30.0
		嘉農秈11號	643.0	47.0	35.0	16.2	98.2	15.3
南投 Nan-tou	草屯	嘉農秈8號	35.0	1.4	7.0	5.6	14.0	40.0
		嘉農秈11號	610.0	41.0	50.5	140.0	231.5	38.0
	南投	嘉農秈8號	158.0	25.2	40.2	54.2	119.6	75.1
		嘉農秈11號	230.0	27.6	82.8	55.2	165.6	72.0
	小計	嘉農秈8號	193.0	26.6	47.2	59.8	133.6	69.2
		嘉農秈11號	940.0	68.6	133.3	195.2	397.1	42.2

總　　計 Total	嘉農秈8號	1,702.0	631.0	367.9	274.7	1,273.6	74.83
	嘉農秈11號	4,270.3	739.1	246.1	251.1	1,236.3	28.95

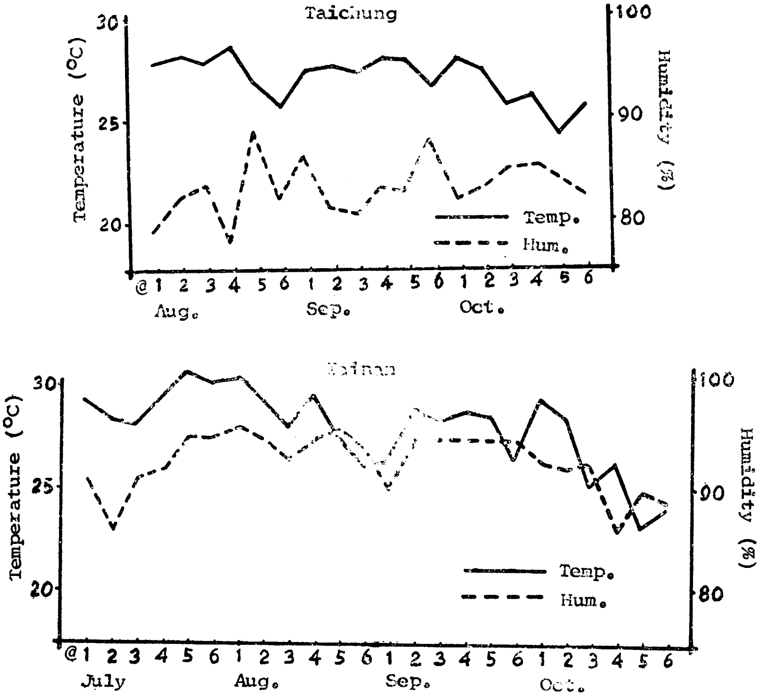
* 示穗稻熱病被害程度：輕＝5％以下，中＝5.1～20%，重＝20.1%以上。

據表一，可知四縣市所栽培的嘉農秈8及11號皆受穗稻熱病爲害，且相當嚴重，其中斗六鎮之發生面積率竟達 100%，即所栽培之稻田裡皆受其害。被害最輕微之鄉鎮爲臺南縣歸仁鄉及雲林縣二崙鄉的嘉農秈11號。由各鄉鎮（除嘉義市）四縣的總計，得知嘉農秈8號之被害面積比嘉農秈11號爲廣，高達栽培面積的74.83%。嘉農秈11號較少，雖然如此，其發生面積率亦達28.95%之多，由此可知此兩品種在該期作受害之嚴重性。

自發生經過觀之，在稻生育前期的葉稻熱病均無發生，或發病輕微，但於抽穗前，劍葉伸長後，其葉節首先受害（劍葉與葉鞘鄰接的位置），故嚴重者在尚未抽穗前（尚包在葉鞘內）的幼穗可能已被感染，而抽穗後則變成白穗。如果葉節部位被害程度爲輕微，但抽穗時稻穗必須經過該部位，因此當穗抽出過程中必定與該被害部位有所接觸，此時稻穗即最易受病原菌之感染，而抽穗後就現出病徵（穗稻熱病）[1,3,5]。據田間調查，受害之稻穗，約90%以上之葉節部位皆受侵害。

2. 稻作期間之氣象

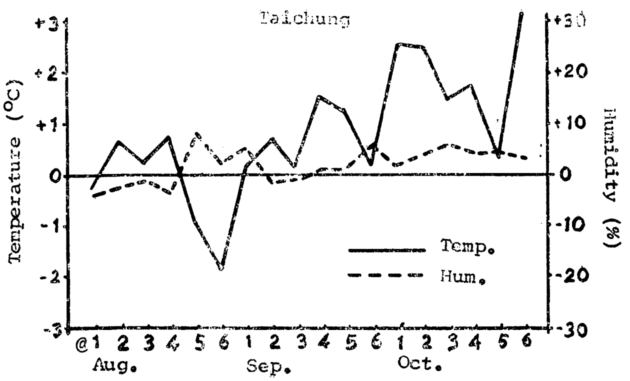
稻熱病發生之程度常受溫度之影響[2,10,11]，即病原菌的分生胞子之發芽，侵入寄主及形成胞子等之過程中，其最適當溫度爲 25～28°C，且濕度須高（90%以上），故雨、露水亦與發病有密切關係。氣溫高低不定之環境下[10]是減低稻抵抗力的原因。如此稻熱病發生與氣候之關係極爲密切。

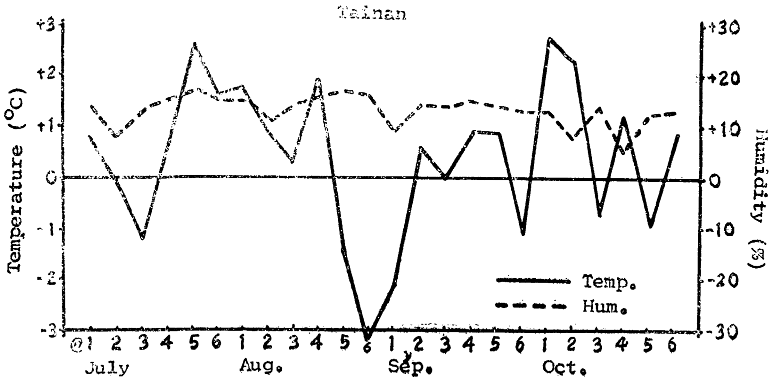


@: 1 indicates first 5 days; 2, second 5 days; 3, third 5 days, etc., of the month.

圖一、1974年第二期稻作期間氣溫、濕度記錄

Fig. 1. Records of temperature and humidity in the second crop of 1974.





@: 1 indicates first 5 days; 2, second 5 days; 3, third 5 days, etc., of the month.

圖二、1974年第二期稻作期間氣溫及濕度與平年之比較

Fig. 2. A comparison of 5-year average temperature and humidity with those in the second crop of 1974.

據臺南區與臺中區六十三年度第二期稻作栽培期間之氣溫與濕度紀錄（圖一），得知臺南區氣溫除 7 月第 5 ，6 半旬及 8 月間之外皆在 25～30°C 之間，臺中地區自 8 月初至10月底都在 25～28°C 之間，頗適合稻熱病病原菌之繁殖，同時濕度亦高，例如臺南地區都在90%以上，亦頗適合稻熱病之發生條件。再與平年之比較（圖二）觀之，無論臺中或臺南均於 8 月第 5 及 6 半旬之平均溫度比平年低 2～3°C ，以後之氣溫都比平年高一些（臺中地區）；濕度在臺南地區 7 ～10月之間皆比平年高，而臺中地區一般亦比平年之濕度爲高。但降雨量在稻作栽培期間皆比平年爲少，而濕度比平年高，由此可知陰天日數多，反之，日照時數亦比平年少。總之，氣溫及濕度頗適合稻熱病菌之繁殖條件下，加以連續陰天，缺乏日照時數之環境，係助長稻熱病發生之主要因素。

稻熱病菌生理型之測定

1.材料及方法

（1）材料：民國63年11月 7 ～10日曾前往嘉義、雲林及南投等縣採集嘉農秈 8 、11號受稻熱病被害標本（臺南縣已收穫，故未能採到）。自被害穀粒分離病原菌並編號，然後行單胞分離，並應用 Yeast starch agar 培養繁殖分生胞子（10～14天）後作成胞子懸浮液，以供人工接種之用。

另於溫室內培育16判別稻種（品種名稱如表三內），即各品種播種於鉛製（7×7×10cm）之四方形小盤中，待秧苗長達 3cm 左右時，每盤追肥 2 %硫酸錏溶液 30ml 。迨秧苗生長達本葉 4 ～ 5

片時供各菌株人工接種之用。

（2）方法：人工接種係應用噴霧接種方法，於接種室將上述胞子懸浮液用小型噴霧器（玻璃製）均勻噴射於各判別稻種之秧苗葉片上，然後保持適當溫、濕度，經24小時後移置於溫室內，再經6～7天後觀察各菌株對判別品種之致病反應。

致病反應係按各判別稻苗所呈之病斑型分爲感病性 (Susceptible)，中間性 (Moderately resistant) 及抗病性 (Resistant) 等三級，作爲生理小種分類之依據。其病斑型之類別基準如表二。

表二、病斑型之類別基準

Table 2. Disease lesion type classification

病斑型 Lesion type	病斑形狀 Lesion shape	病斑色澤 Lesion color
R (抗病性)	無病斑或小斑點或小病斑，直徑 1 mm 以內	褐色乃至黑褐色
M (中間性)	各種形狀的病斑，直徑 2mm 以內	褐色病斑，外圍有明顯邊緣，中央部稍帶灰白色或條斑
S (感病性)	大紡錘形或類似形狀	病斑大形，中央部呈綠灰色，或灰白色，邊緣呈褐色，有的病斑現水浸狀態，其外圍無一定的邊緣

2.測定結果及討論

本研究所測定菌株採自嘉義縣30菌株，雲林縣31菌株，南投縣24菌株計85菌株，經人工接種測定對16判別稻種之致病反應結果，列於表三、四及五。

表四、稻熱病菌生理小種之分佈狀況

Table 4. Distribution of physiological races of rice blast fungus

Race / Country	I													T		K				N	A	菌株數 Total no. of isola.	生理型數 Total no. of races
	20	21	22	31	32	40	41	42	51	52	53	54	55	29	30	2	17	34	48	3	1		
嘉義 Chia-yi	—	—	—	5	—	1	—	3	4	1	1	1	9	—	1	2	—	—	—	—	2	30	11
雲林 Yun-lin	2	—	—	3	—	—	—	3	3	—	2	2	3	1	1	1	3	1	1	3	2	31	15
南投 Nan-tou	—	1	1	1	1	1	1	1	4	5	1	1	—	—	1	—	1	2	—	1	1	24	16
總計 Total	2	1	1	9	1	2	1	7	11	6	4	4	12	1	3	3	4	3	1	4	5	85	21

表三、長粒型秈稻穗稻熱病病原菌之生理小種類別

Table 3. Classification of physiological races of panicle blast in long grain rice

Race / Diff. Variety	I					
	20	21	22	31	32	40
Kung-shan-wu-shen-ken	R*	S	S	S	S	S
Taichung 65	R	S	S	S	S	S
Pai-kan-tao	R	R	R	R	R	R
Taichung 171	R	R	S	R	S	S
Chianung 242	R	R	S	R	R	S
Kwang-fu 1	R	R	S	R	R	R
Chianung-yu 280	R	R	S	R	R	R
Taichung-line 33	R	S	S	R	R	R
Kanto 51	R	R	R	R	R	R
Norin 21	R	R	R	R	R	R
Sensho	R	R	R	R	R	R
Cutsugulcul	R	S	S	R	R	S
Natala	R	S	S	R	S	S
Kao-chio-liu-chou	S	S	S	S	S	S
Kaohsiung-ta-li-chen-yu	S	S	S	S	S	S
Taichung-ti-chio-wu-chien	S	S	S	S	S	S
Code number of isolates	** 4y-11-11 4y-11-13	4s-11-10	4s-11-1	4c- 8- 5 4c- 8- 8 4c- 8-28 4c-11- 5 4c-11- 8 4y- 8-11 4y-11-17 4y-11-32 4s-11- 8	4s-11-12	4c- 8-29 4s- 8- 2

Note: * R=Resistant: S=Susceptible.

** 4y-11-11=4=Collected in 1974; y=locality (y=yun-lin, C=chia-yi; S=Nan-tou)., 11=Code no. of rice variety

(11=Chianung-shien 11; 8=Chianung-shien 8)., 11=Different isolate no. from same variety.

(續表三)

Diff. Variety \ Race	I						
	41	42	51	52	53	54	55
Kung-shan-wu-shen-ken	S	S	S	S	S	S	S
Taichung 65	S	S	S	S	S	S	S
Pai-kan-tao	R	R	R	R	R	R	R
Taichung 171	S	S	S	R	R	S	S
Chianung 242	S	S	R	R	R	R	S
Kwang-fu 1	R	R	R	R	R	R	R
Chianung-yu 280	R	R	R	R	R	R	R
Taichung-line 33	R	R	S	R	R	R	R
Kanto 51	R	S	S	R	S	S	S
Norin 21	R	R	S	R	S	R	R
Sensho	R	R	S	R	R	S	S
Cutsugulcul	R	S	S	R	R	R	R
Natala	R	S	S	S	R	S	R
Kao-chio-liu-chou	S	S	S	S	S	S	S
Kaohsiung-ta-li-chen-yu	S	S	S	S	S	S	S
Taichung-ti-chio-wu-chien	S	S	S	S	S	S	S
Code number of isolates	4s-11-15	4c- 8- 1 4c- 8- 2 4c- 8- 6 4y-11- 6 4y-11-18 4y-11-25 4s- 8- 9	4c- 8- 4 4c- 8- 7 4c- 8-11 4c- 8-30 4y-11- 2 4y-11-20 4y-11-27 4s- 8- 1 4s-11- 3 4s-11- 5 4s-11-14	4c- 8-16 4s- 8- 6 4s- 8-15 4s-11- 6 4s-11-13 4s-11- 6	4c- 8-25 4y-11- 5 4y-11-28 4s- 8-17	4c- 8-24 4y-11- 7 4y-11-31 4s-11- 2	4c -8-14 4c- 8-15 4c- 8-18 4c- 8-19 4c- 8-20 4c- 8-21 4c- 8-22 4c- 8-23 4c- 8-26 4y-11-22 4y-11-29 4y-11-33

(續表三)

Race / Diff. Variety	T		K				N	A
	29	30	2	17	34	48	3	1
Kung-shan-wu-shen-ken	S	S	S	S	S	S	R	R
Taichung 65	S	S	R	S	R	S	R	R
Pai-kan-tao	R	R	R	R	R	R	R	R
Taichung 171	R	S	R	R	R	S	R	R
Chianung 242	R	S	R	R	R	R	R	R
Kwang-fu 1	R	R	R	R	R	R	R	R
Chianung-yu 280	R	R	R	R	R	R	R	R
Taichung-line 33	R	R	R	R	R	R	R	R
Kanto 51	R	R	R	R	R	R	R	R
Norin 21	R	R	R	R	R	R	R	R
Sensho	R	R	R	R	R	R	R	R
Cutsugulcul	R	R	R	R	R	R	R	R
Natala	S	S	R	R	S	R	S	R
Kao-chio-liu-chou	R	R	R	R	R	R	R	R
Kaohsiung-ta-li-chen-yu	R	R	R	R	R	R	R	R
Taichung-ti-chio-wu-chien	R	R	R	R	R	R	R	R
Code number of isolates	4y-11- 3	4 - 8-12 4y-11-34 4s- 8-31	4c- 8-10 4c- 8-13 4y-11- 9	4y- 8-14 4y-11-16 4y-11-23 4s- 8- 8	4y-11-21 4s-11- 4 4s-11- 7	4y-11-12	4y-11-14 4y-11-15 4y-11-19 4s-11-11	4c- 8- 3 4c- 8- 9 4y-11-10 4y-11-30 4s- 8- 3

表五、嘉農秈 8，11號與稻熱病菌生理小種之關係

Table 5. Relation of physiological races of rice blast fungus to Chianung-shien 8 and 11.

Race / Variety	I													T		K				N	A	菌株數 Total no. of isola.	生理型數 Total no. of ruces
	20	21	22	31	32	40	41	42	51	52	53	54	55	29	30	2	17	34	48	3	1		
嘉農秈8號 Chianung-shien 8	—	—	—	4	—	2	—	4	5	3	2	1	9	—	2	2	2	—	—	—	3	39	12
嘉農秈11號 Chianung-shien 11	2	1	1	5	1	—	1	3	6	3	2	3	3	1	1	1	2	3	1	4	2	46	20
總　計 Total	2	1	1	9	1	2	1	7	11	6	4	4	12	1	3	3	4	3	1	4	5	85	21

據表三、得知供試85菌株對16判別稻種之致病反應，經測定結果可類別爲五羣；包括21種不同生理型。其中和往年已出現之生理型相同者有16種（即 race 20 21, 22, 31, 32, 40, 41, 42, 29, 30, 2, 17, 34, 48, 3, 及 1 等）[6,7,8,9]。由本次測定新出現之生理小種有五種；編號爲 Race 51, 52, 53, 54 及55，皆屬於 I Group。其主要致病反應是對崑山五香粳、臺中 65號及臺灣平地在來稻（高脚柳州、高雄大粒清油、臺中低脚烏尖）等判別品種呈感病性（S）反應。此等新出現的生理小種中，有些對臺中 171 號、臺中系比 33號、關東 51號、農林21號、 Sensho, Natala 及 Cutsugulcul 等（Race 51），有些對 Natala（Race 52），有些對農林21號及關東51號（Race 53）， 有些對臺中171號，關東51號， Sensho 及 Natala 等 （Race 54），有些對臺中171號，嘉農 242號，關東51號及 Sensho 等（Race 55）皆呈感病性（S）反應，而對其餘判別品種均呈抗病性（R）反應。

21種不同生理小種中，屬於 I 羣者有13種（佔61.9%）之多，其中以 Race 55 之出現頻度最多，其次爲 Race 51 再次爲 Race 31 ；屬於T羣者 2 種（佔9.5%）；屬於 K 羣者 4 種（佔19.0%）；屬於N及A羣者各 1 種（各佔 4.8%）。由此可知侵害在來稻的生理小種之出現頻度頗高。目前本省所栽培水稻，僅可類別爲蓬萊稻（屬 Japouica type）和在來稻（屬 Indica type），而且蓬萊稻中頗多品種都導入印度型稻的血統，以育成豐產而抗稻熱病之品種，但現在已知可侵害印度型稻的稻熱病菌生理型頗多的環境下，今後對稻熱病之發生消長，吾人需特別提高警覺。

由稻熱病菌生理小種之分佈狀況觀之，嘉義縣的生理小種數計 11種，其中以 Race 55 之出現頻度最多，其次爲 Race 31； 雲林縣計15種，其中出現頻度最多亦僅有 3 菌株（Race 31, 42, 51, 55, 17 及 3 等）；南投縣供試菌株數最少，但其生理小種數達16種之多，以 Race 52 之出現頻度最多，其次爲 Race 51, 其餘生理小種均僅有 1 菌株而已。

如果以品種間之差異而言，自嘉農秈 8 號分離所得之生理小種數計12種，其中以 Race 55 之出現頻度最多，其次爲 Race 51, 再其次爲 Race 31及42。自嘉農秈11號分離所得之生理小種數計20種，其中以 Race 51 之出現頻度最多，其次爲 Race 31, 再次爲 Race 30。此現象可能受栽培面積多寡之影響。

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A SURVEY ON THE PREVALENCE OF PANICLE BLAST OF THE LONG GRAIN *INDICA* TYPE RICE, WITH SPECIAL EMPHASIS ON THE PHYSIOLOGICAL RACES OF BLAST FUNGUS

by

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Summary

The present study was conducted to survey the prevalence of panicle blast in the long grain *indica* type rice varieties, Chianung-shien 8 and Chianung-shien 11. 74.83% of 1,702 hectares of Chianung-shien 8 and 28.95% of 4,270 hectares of Chianung-shien 11 were heavily damaged by the disease in the 2nd crop of 1974. In addition to the panicle part, the collar of the leaves were also severely infected by the disease.

The panicle samples were collected from different diseased areas and the pathogen isolated. The isolates of the pathogen were tested to identify the races based on the disease reaction types on the 16 differential rice varieties. Twenty one races, including 5 new races and 16 previously identified races, were obtained. The further investigation comfirmed that 13 races belong to group I, 2 races belong to T group, 4 races belong to K group, and one race each belong to groups N and A respectively.

It was also found that the races 51 and 55 invade exclusively to Chianung-shien 8 and race 31 and 51 to Chianung-shien 11. Results indicated that there are more races infecting *indica* type rice varieties.